WADC TECHNICAL REPORT 52-193

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TEST AND EVALUATION OF ALTIMETER AN/APN-57

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APRIL 1952

WRIGHT AIR DEVELOPMENT CENTER

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Aircraft Radiation Laboratory

April 1952

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Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

McGregor & Werner, Dayton, O.
150 May, 1953

FOREWORD

This report was prepared to record results of a research and development project identified by Research and Development Order R-108-90, "Airborne Electronic Altimeter for Mapping." The project was under the direction of the Altimeter Section, Aircraft Radiation Laboratory, WADC, with Captain J. Paul Georgi acting as project scientist. Following the transfer of Captain Georgi to another section of the laboratory, Mr. Albert Goldman, Chief, Altimeter Section, completed the preparation of the report.

Acknowledgement is made to Messrs. S. Tomberg, S.A. Segen, J.K. Limoli, and O.M. Minnich of WADC, and to Mr. R.T. Wahl, Jr., formerly of WADC, for their valuable assistance.

ABSTRACT

Sixteen Altimeters AN/APN-57, manufactured by the RCA Victor Division, Camden, N.J., were tested by the Aircraft Radiation Laboratory, Directorate of Laboratories, WADC, and by other agencies. Results of type tests, accuracy tests, ground tests, and antenna pattern measurements are presented. The equipment meets all of the exhibit requirements, provided a calibration error is compensated for during either zero adjustment or data reduction. It is concluded that future devices of this type should include a stabilized antenna system. A higher carrier frequency would permit attaining the same or narrower antenna beamwidth with a smaller antenna. Photographic recording of data is not entirely satisfactory, and other methods are suggested.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDING GENERAL:

Donald J. Beane
for CLARENCE H. LEWIS
Colonel, USAF
Chief, Aircraft Radiation Laboratory
Directorate of Laboratories

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

The preparation of accurate charts and maps from aerial photographs is impossible without reliable vertical control (a method whereby ground elevation with respect to sea level is obtained) in order to establish the contours of the terrain. Many photographic mapping and charting operations will be conducted over enemy territory where no such control data are available. The Army Air Forces Directorate of Photography, therefore, proposed on 4 November 1942 that vertical control be obtained from an aircraft in flight by means of a radio altimeter (providing height of the aircraft above the terrain) and a barometric altimeter (providing height of the aircraft above sea level). Action was taken on this proposal using Radio Set SCR-718-( ) to obtain vertical control, but because of certain inadequacies of the SCR-718-( ), particularly the wide antenna beam, it was concluded that this method was not accurate enough for use over mountainous terrain. It was, therefore, recommended (see Air Technical Service Command, Engineering Division, Memorandum Report No. TSEPL-4-681-149-2, Subject: Vertical Control-Radio Altimeter, dated 7 September 1945), that a project be opened to study and develop a system of vertical control that would be suitable for both flat and mountainous terrain.

A conference (see Appendix I) was held at the Radar Laboratory, AMC, 3 January 1946 and the requirements of an equipment suitable to furnish adequate vertical control were discussed.

On 2 May 1946, Technical Instructions 2204, Addendum 1 (see Appendix II) was prepared at AMC, and from this, a project was established which was identified by Research and Development Expenditure Order 101-99, "Vertical Control Altimeter AN/APN-57," and which was later changed to Research and Development Order R-108-90, "Airborne Electronic Altimeter for Mapping." A letter contract was awarded on 6 June 1946 to the RCA Victor Division, Camden, N.J., for the design and construction of 16 models of the vertical control altimeter. Contract No. W33-038-ac-15029 was signed on 5 May 1947. The first Altimeter AN/APN-57 was delivered by RCA on 9 July 1947. Delivery of all of the contract items was completed on 14 December 1949.

SECTION I - PURPOSE

The evaluation of Altimeter AN/APN-57 described in this report was conducted in order to determine whether the equipment met the requirements of the applicable exhibit and subsidiary specifications.

SECTION II - METHOD OF ATTACK

The evaluation of Altimeter AN/APN-57 was conducted in accordance with established procedures of the Aircraft Radiation Laboratory. The task was broken down into several sections, described in detail in Section III of this report, as follows:

Type Tests
Flight Tests.
Accuracy Tests
Antenna Pattern Measurements
Life Test

SECTION III - FACTUAL DATA AND RESULTS

A. General Description:

Altimeter AN/APN-57, shown in Figure 1, is an airborne equipment designed to indicate the absolute altitude (terrain clearance) of an aircraft. The equipment operates at altitudes between 10,000 and 35,000 feet. Altitude is registered on a servo-operated three-pointer dial which is calibrated from 0 to 100,000 feet. A cathode-ray tube indicator shows the instantaneous error up to ±500 feet in the servo-indicated altitude.

On the error scope the received pulse is displayed as an outwardly directed pulse on a circular trace, while a marker pulse nominally at zero is directed inwardly. The equipment consists of an antenna assembly (Figure 2) and associated trim control box, a transmitter-receiver unit (Figure 3), and an indicator unit (Figure 4). The over-all weight of the complete equipment less cables is 160.4 pounds. The carrier frequency is in the range of 9345 to 9405 megacycles.

The transmitter-receiver is a modified RT-69/APS-10. Output is a pulse of about 0.25-microsecond length and 4-kw peak power. The 60-inch diameter parabolic antenna reflector provides a beam width of about 1.6° at the half-power points. Power requirements are 580 watts at 115 volts, 380-420 cycles, and 32.5 watts at 26.5 volts DC.

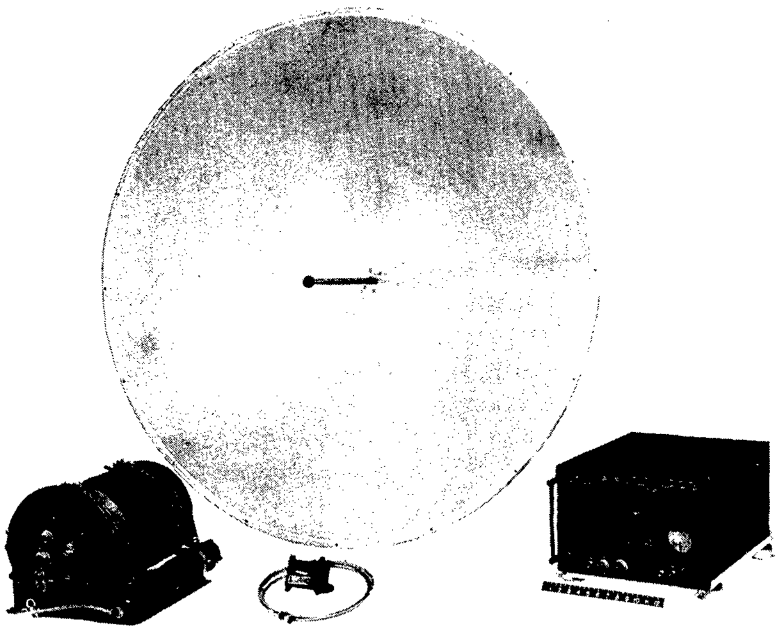


Fig. 1. Composite View of Altimeter AN/APN-57

1. Transmitter-receiver RT-125/APN-57 on mounting MT-292/APS-10
2. Control box C-226/APS-10
3. Antenna assembly AS-368/APN-57
4. Indicator ID-222/APN-57 on mounting MT-613/APN-57

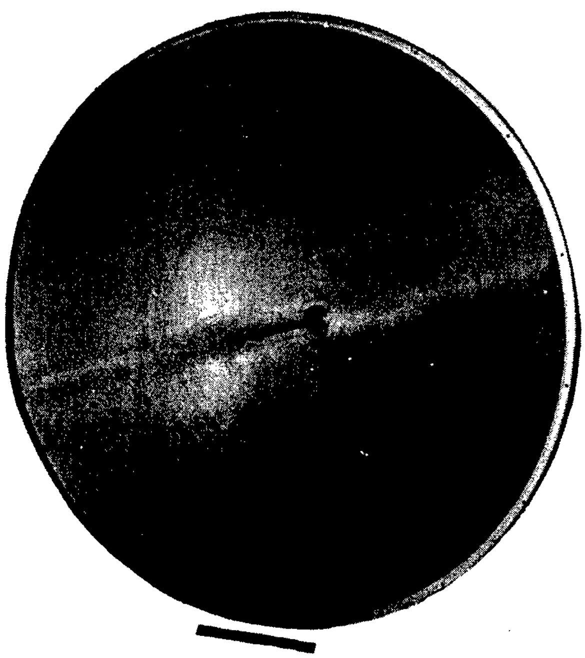


Fig. 2. Antenna assembly AS-368/APN-57 (Front view)

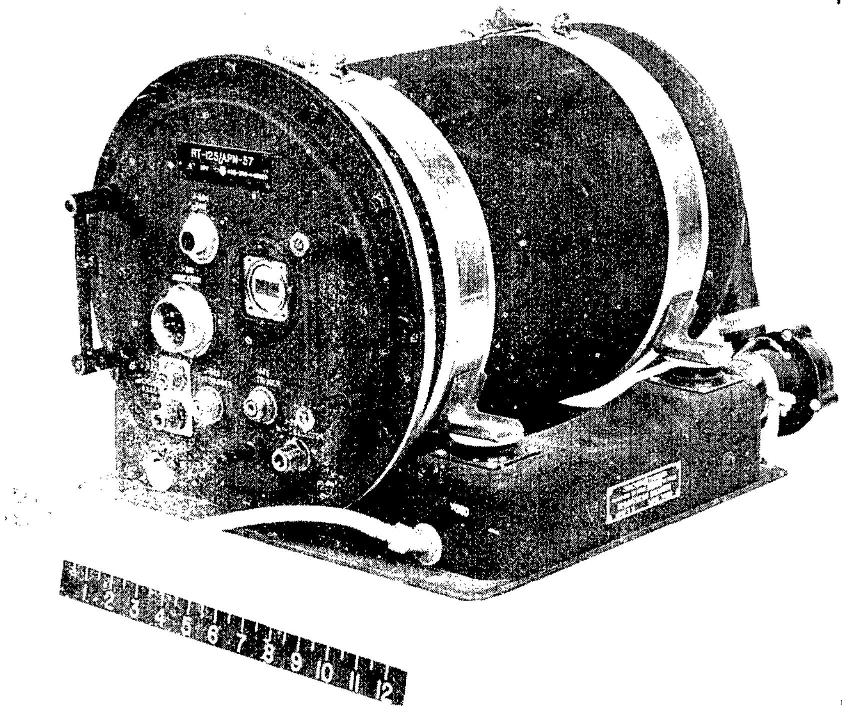


Fig. 3. Transmitter-Receiver RT-125/APN-57 on Mounting MT-292/APS-10 (Front View)

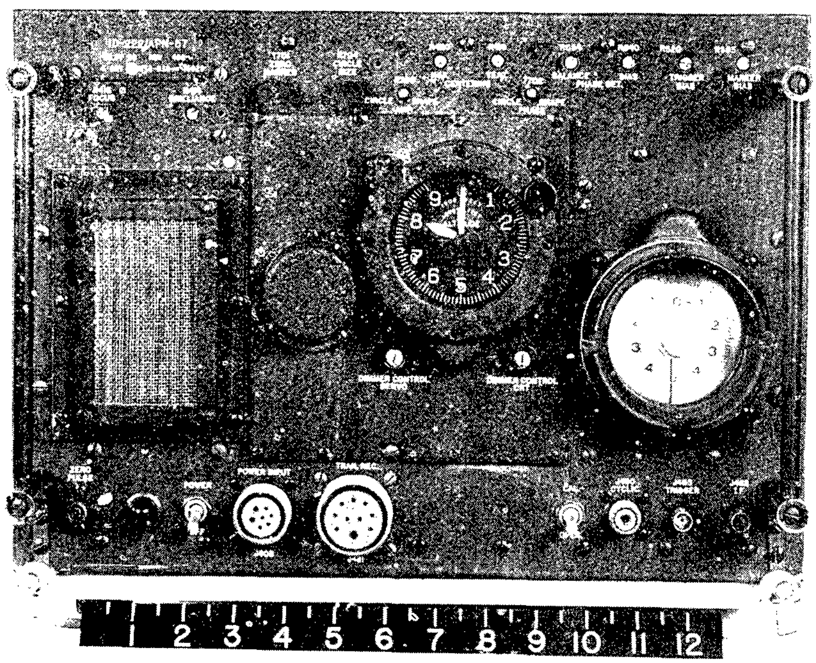


Fig. 4. Indicator ID-222/APN-57 on Mounting MT-613/APN-57

LIST OF MAJOR COMPONENTS

Name of Unit	Type Designation	Weight (lbs)	Size
Antenna Assembly	AS-368/APN-57	31.0	21 17/32 in. 62 7/16 in. diameter
Transmitter-Receiver Unit	RT-125/APN-57	43.5	19 in. x 12 in. diameter
Indicator Unit	ID-222/APN-57	76.0	10 7/8 in. x 15 1/2 in. x 23 in.
Mounting (R-T)	MT-292/APS-10	6.5	
Mounting (Ind.)	MT-613/APN-57	2.3	
Trim Control Box	C-226/APS-10	1.1	4 in. x 3 1/8 in. x 5 13/16 in.

B. Type Tests:

Type tests were conducted on Serial No. 1 in April and May 1948 and on Serial No. 2 in August and September 1948 by the RCA Victor Division, Camden, N. J., and witnessed by WADC observers. The type tests included the following specific tests (paragraph numbers refer to Specification 71-854a):

1. Spot temperatures (Par. D-1m)
2. Temperature range -55°C to +71°C (Par. D-2a(1))
   Measurements were made on goniometer linearity, transmitter output, receiver sensitivity, oscillator frequency, and tracking of the 3kc gate and the 98 kc trigger pulse.
3. Humidity (Par. D-2a(2))
4. Altitude (35,000 feet)
5. High temperature, nonoperating, +85°C (Par. D-2b(1))
6. Humidity, nonoperating (Par. D2b(2))
7. Altitude, nonoperating, 40,000 feet (Par. D-2b(3))
8. Vibration (Par. D-3b)
9. Input voltage and frequency variation, 90 to 135 volts, 300 to 1000 cps (Par. D-4b(1), (2), and (3))

In general, the equipments met the type test requirements satisfactorily. A summary of the results follows:

1. Maximum spot temperatures for eight hot spots were measured and did not exceed the ratings in the five instances for which ratings were available.

2. Goniometer linearity, transmitter power output, timing oscillator frequency, and gate tracking were not appreciably affected by temperature changes. Receiver sensitivity decreased, but not excessively at low temperature.

3. Goniometer linearity was degraded following the humidity test, but returned practically to normal 24 hours later. Transmitter output was not affected by the humidity test. Receiver sensitivity was degraded severely by humidity and did not recover (in set #1) within 24 hours. The focus of the oscilloscope of one indicator was affected, but recovered 15 minutes after the test.

4. The equipment operated satisfactorily for 15 minutes at a pressure equivalent to an altitude of 40,000 feet.

5. The equipment operated satisfactorily following the high temperature (nonoperating) test.

6. The equipment operated satisfactorily during the vibration test except for the failure of one tube while the direction of vibration table movement was being changed from horizontal to vertical.

7. The indicator operated satisfactorily with input power source variations from 90 to 135 volts and 300 to 1000 cps, but the transmitter-receiver AFC would function only between 110 and 120 volts. Detailed type test procedures and results will be found in Appendix IV of this report.

C. Flight Tests:

Installation:

Upon receipt of the first Antenna Assembly AS-368/APN-57, 2 May 1947, plans for installation of Altimeter AN/APN-57 in Photographic Laboratory aircraft (type B-29, number 43-65223) were made. Because of the size of the antenna the only location available for it was in the rear bomb bay (see Figure 5). Transmitter-Receiver RT-125/APN-57 was installed in the rear bomb bay on a platform above the antenna mount (see Figure 6) so that the waveguide transmission line would be as short as possible. Indicator ID-222/APN-57 was installed on a table in the rear pressurized section just forward of the left scanner's position (see Figure 7).

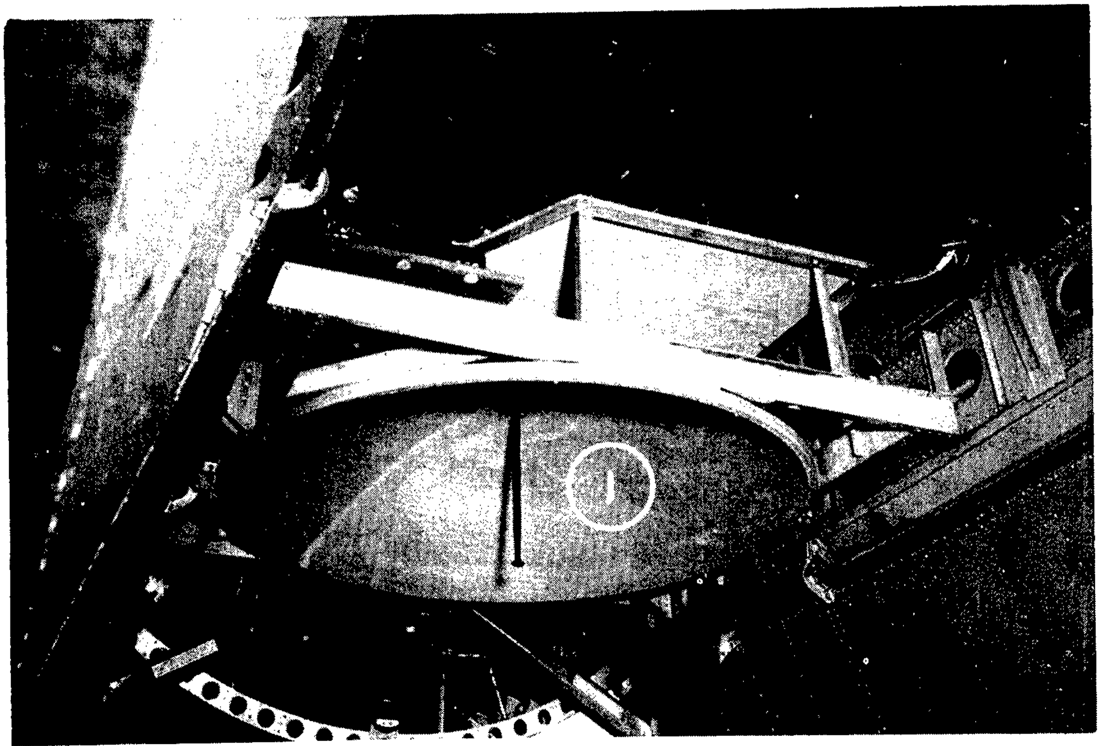


Fig. 5. Antenna Installation

1. Antenna assembly AS-368/APN-57

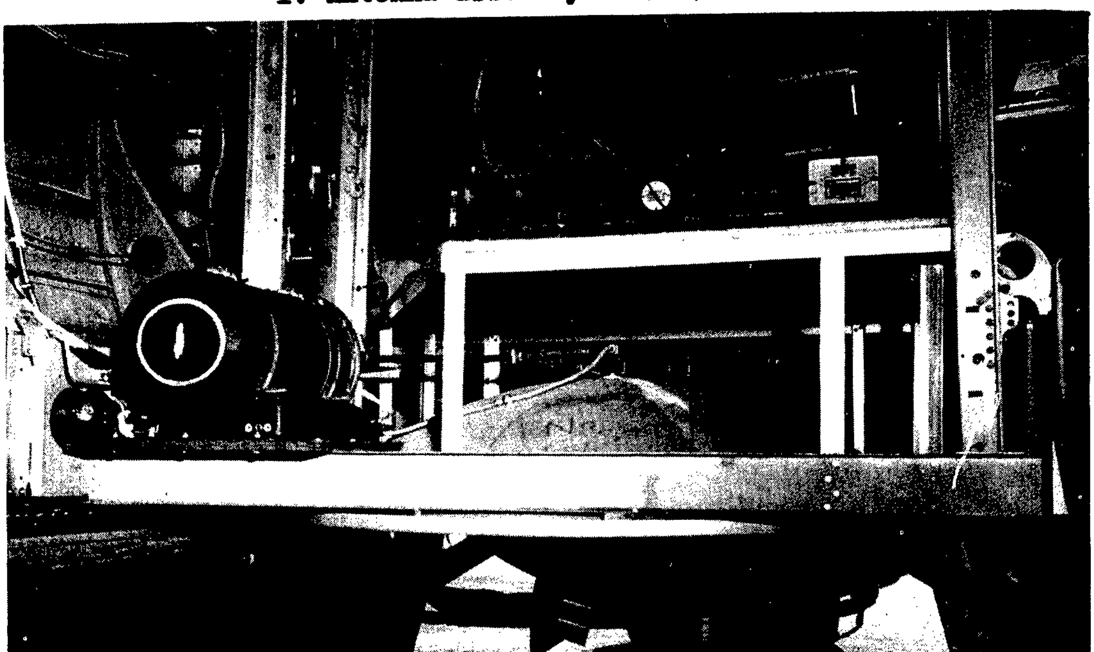


Fig. 6. Transmitter-Receiver Installation

1. Transmitter-receiver RT-125/APN-57

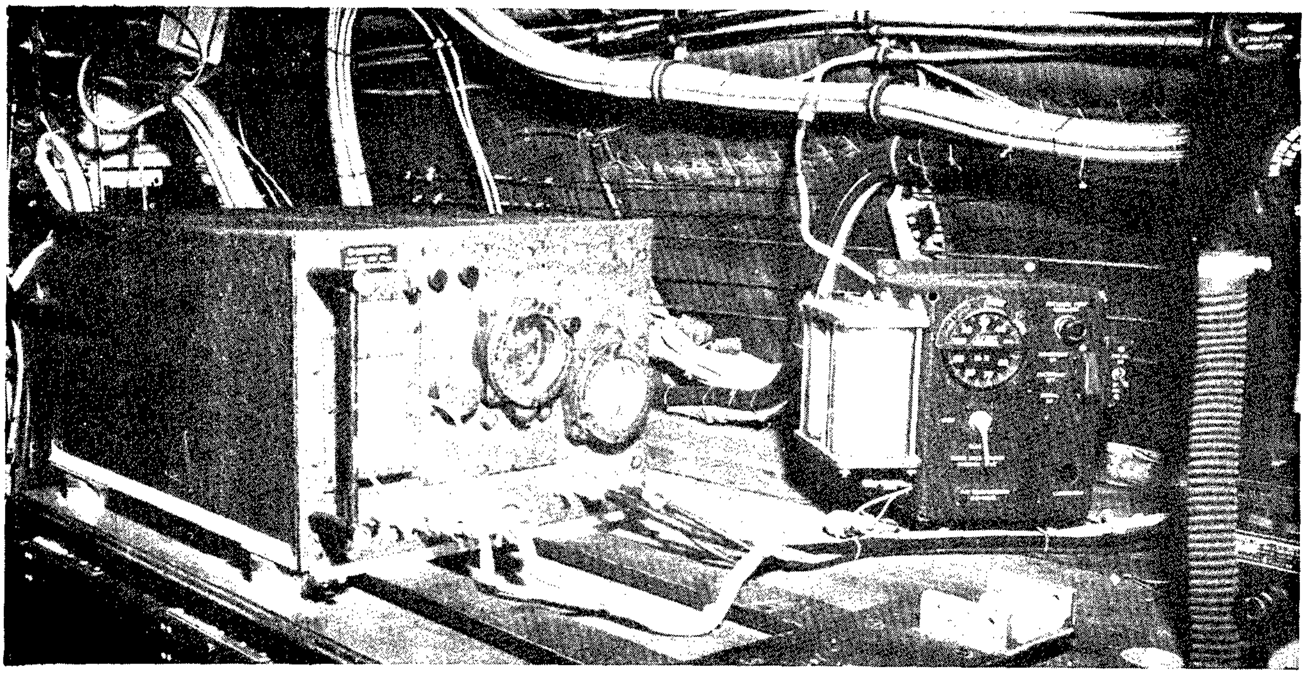


Fig. 7. Indicator Installation

1. Indicator ID-222/APN-57

Local Flight Test:

This flight was conducted in B-29, No. 43-65223, on 11 July 1947 and was considered a performance demonstration of the altimeter by the manufacturer. The terrain flown over in this flight was rather flat, with a few hills of less than 300 feet in height; during normal flight, banking, and climbing, the following observations were made:

a. Performance of the AN/APN-57 was adequate down to 8,000 feet; the exhibit requires operation between the altitudes of 10,000 and 35,000 feet.

b. The 3-pointer meter in the indicator was fairly steady and easily read, but the error indicator was difficult to read at times. The error indications were much steadier over water (Lake Erie).

c. Over water at times the reflected signal momentarily became so strong that the AGC reduced the amplitude of the indicated pulse about one-third of normal. This is explained by the fact that the AGC of the AN/APN-57 had been adjusted for the flight tests conducted in the manufacturer's own airplane (AT-11) which had a small 18-inch parabolic reflector instead of the high gain 60-inch reflector used in the B-29.

d. Over water, during banks, the signal pulse disappeared and the hand on the 3-pointer meter tended to return to zero. Over land, sufficient radiation was returned by scattering so that banking the airplane did not have such an effect, although a slight increase in the indicated altitude was noted.

(In a previous flight in the manufacturer's AT-11 with the 18-inch antenna the AN/APN-57 did not work nearly so well as in the B-29. The former flight had been conducted over hilly land, which may have been one reason for the poorer performance of the AN/APN-57.)

It was concluded from this flight that: (1) the error indicator might be difficult to read and photograph, (2) performance over hilly terrain needed further investigation, and (3) there was a possibility that if the airplane were not level a slant range error might be introduced.

Colorado Flight Test (August 1947):

This was another performance test of the AN/APN-57 conducted in B-29 No. 43-65223, over high mountains (12,000 to 15,000 feet), sandy soil, and water. The course flown was west from Lowry AFB, Denver, Colorado, over the mountains toward Mt. Powell, (13,543 feet) at an altitude of 20,000 feet. The heading was then changed to south at 25,000 feet from Mt. Powell to Mt. Elbert (14,431 feet). The flight was then continued south at 30,000 feet over Twin Lakes. This terrain included a large sandy plateau. The following observations were made:

a. Performance of the AN/APN-57 was good, except that once for about 15 seconds the error scope displayed two distinct pulses, one indicating a positive, and the other a negative correction, making it impossible to determine which to use as the correction. The terrain at this time was mountainous and the ground coverage by the antenna beam more than 10 acres; multiple reflections are common under such conditions, but the servo system is usually able to lock on the earliest and strongest signal.

b. The equipment performed satisfactorily with a terrain clearance of only 6000 feet, exceeding the exhibit requirement (10,000 feet) by a good margin.

Photographs were made of the indicators in operation, but because of improvised nature of the camera setup, the results were unsatisfactory. After this flight test program on the first model of AN/APN-57, the equipment was returned to the contractor for rework and for use as a guide in fabrication of the remaining models.

D. Accuracy Tests:

Phoenix, Arizona (February 1949):

The first reworked equipment was delivered in June 1948. A flight was made over a ground-control area near Phoenix, with photographs made simultaneously of the ground, using type T-5 and T-9 aerial cameras, and of the AN/APN-57 indicator readings. The film records were turned over to the Mapping, Charting, and Reconnaissance Research Laboratory, Ohio State University Research Foundation, Columbus, Ohio, for analysis and computation on a photogrammetric basis. The AN/APN-57 average error was found to be +80 feet in 20,000 feet, exceeding the specified limit (±0.2% of the indicated altitude.) The contractor was therefore asked to eliminate this error. The complete report of these tests is included in Ohio State University Research Foundation Technical Paper 55, 30 April 1949, "Report of Phoenix Mission Accuracy Tests Made on Radio Altimeter AN/APN-57".

Ground Tests (First Series, July and August 1949):

Since it was the opinion of the RCA engineers that the 80-foot error was not entirely due to the altimeter and that the greater portion of the error arose in the photographic scaling and interpretation, a ground test was arranged. A surveyed range of 10,500 feet with stakes at 125-foot intervals was laid out at Area C, WPAFB. A corner reflector, mounted on a platform (see Figure 8) 30 feet high and 2000 feet from the nearest large object, was used as the target. Altimeter AN/APN-57 was installed in a panel truck with the antenna directed out from the rear end of the truck (see Figure 9). The truck was then positioned so that the focal point of the antenna was directly above one of the stakes. Readings of range were taken at 125-foot intervals with various combinations of each of 15 equipments at ranges between 5000 and 10,000 feet. In 16 valid runs the average error was +42.6 feet. Complete data are given in Appendix V.

Each indicator had either a partial or a major failure before completion of the test. For this reason, and since the mean error of all the equipments fell outside the exhibit limits, the equipments were all returned to the contractor for repair and study of the cause of the error.

Ground Tests (Second Series, October 1949):

Upon completion of the debugging process by the contractor the equipments were returned to WPAFB. The second series of ground tests was conducted with the assistance of the contractor's project engineer, Mr. Keith Law. Based on the results of the first series of ground tests a compensating "error" of -40 feet was inserted during calibration. The mean error of 63 readings (see Appendix VI) was now only -2 feet. It was decided that the equipment would be accepted if it were proved that the same fixed error existed during flight tests as that which was present during the ground tests, It would then be possible to cancel this error by proper zero adjustment.

Edwards AFB Accuracy Tests (March 1950):

The altimeter accuracy tests were made on the precision bombing range, Edwards AFB, Muroc, California, which has facilities for determining from the ground the absolute altitude of an aircraft in flight (with a claimed accuracy of ±5 feet at 25,000 feet). These facilities were operated by the Aberdeen Bombing Mission of the Army Ordnance Department.

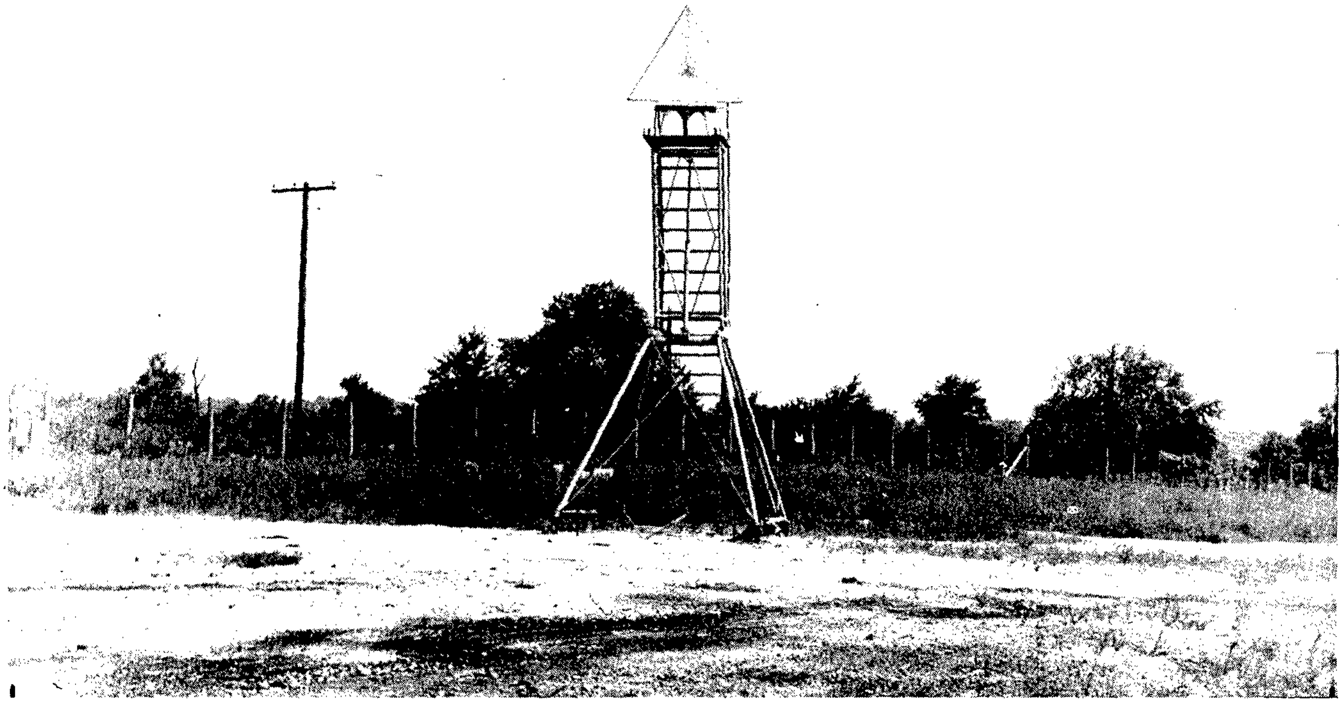


Fig. 8. Corner Reflector Target

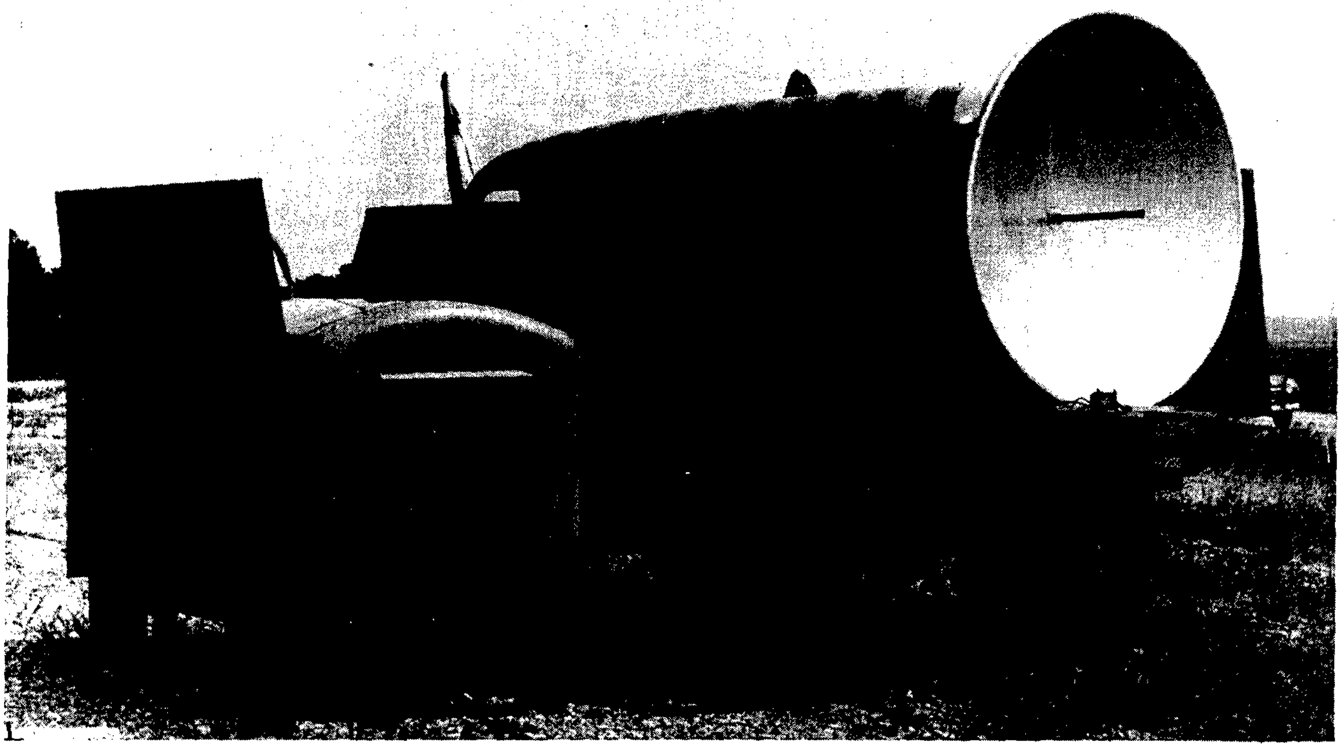


Fig. 9..Antenna Mounted on Truck

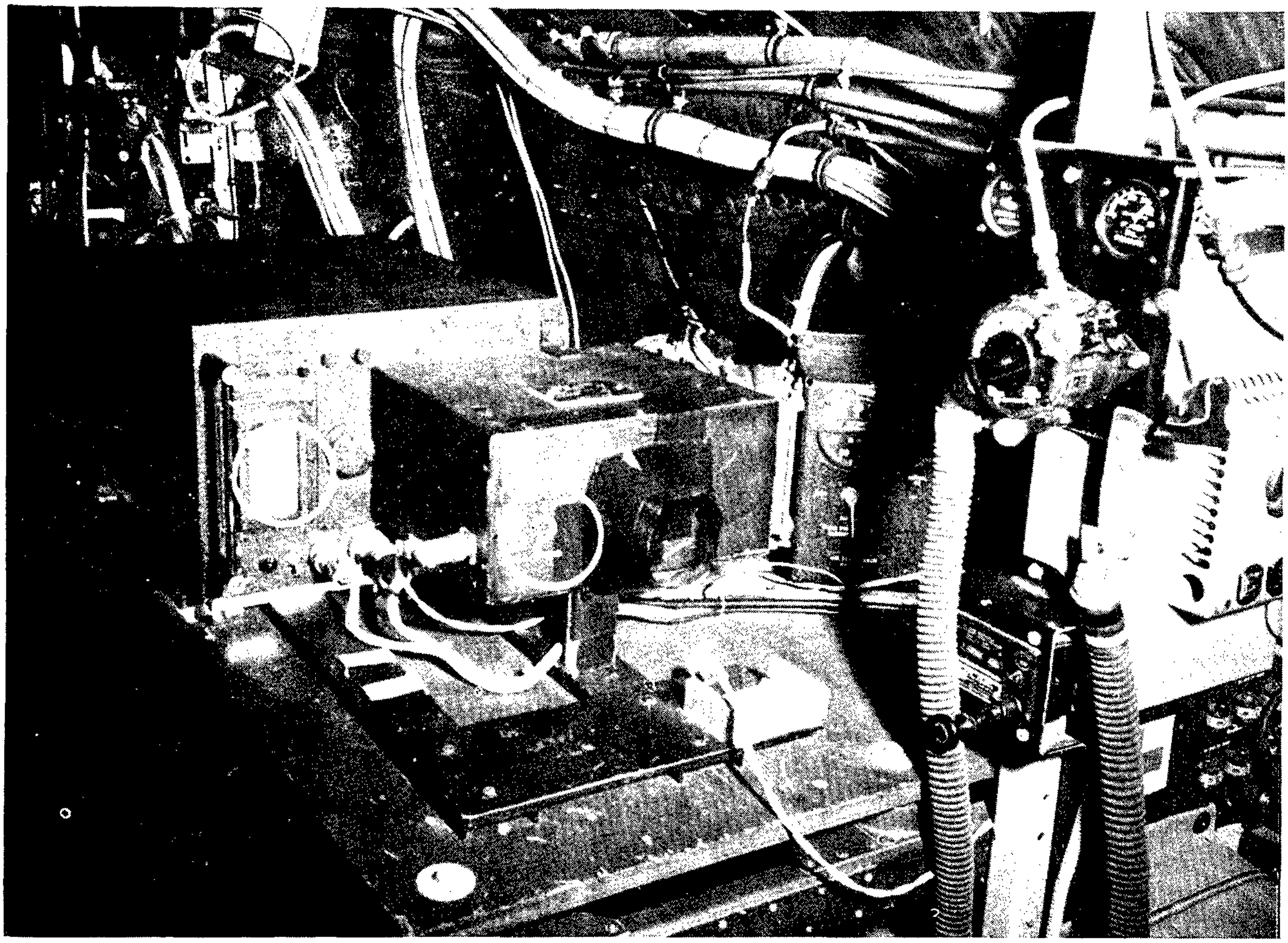


Fig. 10. Indicator and Photo Recorder Installation

1. Indicator ID-222/APN-57
2. Photo recording box

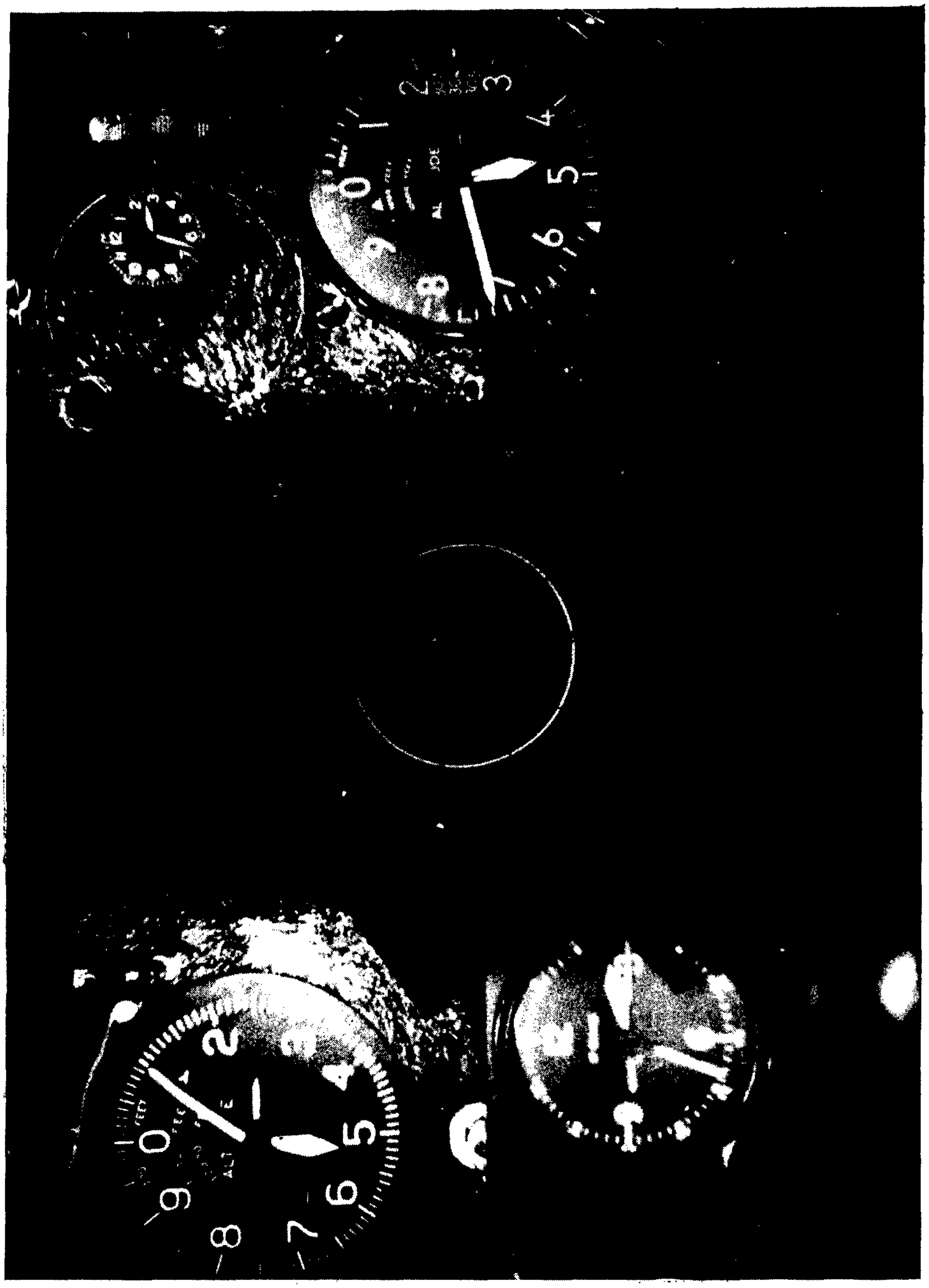


Fig. 11. Sample Frame of Film Record

The test procedure was as follows: The altimeters and associated camera equipment were mounted in the waist of a B-29 (see Figure 10); the AN/APN-57 transmitter-receiver and antenna were mounted in the rear bomb bay. The plane was flown at about 25,000 feet altitude on a course midway between two ground camera positions. Synchronizing signals from a ground control position were sent by radio to the aircraft; these signals triggered a high intensity flash mounted on the underside of the plane, and operated cameras located in front of the AN/APN-57 indicator and bank and turn indicator. Thus at the instant the shutters of the ground cameras were opened, the light on the plane flashed and the cameras in the plane recorded the readings of all instruments involved in the test. The flash from the plane produced a well-defined dot on the plates of the two ground or "ballistic" cameras. This information enabled the Ordnance personnel to determine the position of the aircraft in space with reference to the cameras. Later, an accurate survey of the point directly beneath the aircraft on the bombing range allowed the absolute height of the aircraft to be determined. The synchronizing signals were coded in such a way that the altimeter readings could be properly compared with the absolute height of the aircraft as measured from the ground. Tests were made over the bombing range during the week of 20-24 March 1950 (see Appendix VII for the test program and detailed results). Successive passes with the aircraft in straight and level flight and in various degrees of bank and climb were made. See Figure 11 for a sample frame of the recorded data.

Two local flights were also made during this week, and the behavior of the altimeter was observed over various types of terrain. On at least one occasion, while the aircraft was over heavy clouds, the AN/APN-57 indicator went to its maximum limit, then soon returned to normal operation. At the same time, Radio Set SCR-718-C and Radar Set AN/APQ-13 became unreadable. It is likely that the combination of rough terrain and heavy clouds greatly attenuated and dispersed both the transmitted and reflected signals. At all other times the AN/APN-57 operated normally in flight.

Accuracy tests were continued the week beginning 27 March, with the aircraft at an altitude of about 16,000 feet. Passes over another type of ground camera known as the Askania were included; the Askania is somewhat more flexible to use than the ballistic type, but the accuracy of measurement is not so good. A total of four different AN/APN-57 indicator units (No. 5, 7, 14, and 15) were used. Altitude readings were taken as the aircraft went through various banking angles up to a maximum of 33°. The altimeter operated during even the most severe bank, but the dial reading increased some hundreds of feet for small banking angles (below 10°) and some thousands of feet at the maximum angle.

The foregoing tests were all run with the altimeter calibrated in the usual fashion, without attempting to correct for the "calibration error," which had been found to be approximately 40 feet in the ground tests. The average error of 83 readings over the desert near the dry lake, corrected for tilt (bank and climb) but excluding all runs for which tilt angles were greater than 3°, was 41.9 feet, corresponding closely to the ground test error of 42.6 feet. Also excluded were two runs during which the antenna feed was displaced 6° from its center position, and the last two runs, which were over the dry lake. During the last two runs Askania cameras were used, because the flight path was out of range of the ballistic cameras; the errors of Altimeter AN/APN-57, Radar Set AN/APN-42(XA-2), and Radio Set SCR-718-C were all significantly changed in the negative direction compared to the readings of the previous 17 runs. It is not known which of the new conditions (dry lake vs. desert and Askania vs. ballistic cameras) was responsible for this effect. Possibly both factors were involved. It is a fact that servo-controlled pulse altimeters such as the AN/APN-57 and AN/APN-42(XA-2) will read higher (other factors being the same) over rough terrain than over smooth terrain, because of the multiplicity of slant range reflections. Radio Set SCR-718-C is not a servo-controlled altimeter, but an equivalent effect may have been present because of broadening of the leading edge of the reflected pulse as seen on the indicator oscilloscope.

The average error of 83 readings uncorrected for tilt was 53.9 feet. The minimum tilt-corrected error (average of a single run) was 21.2 feet and the maximum was 57 feet. A summary of the run averages, with vector tilt angles and tilt corrections, is given in Table I. Vector tilt is the vector sum of the bank angle and the climb angle; the tilt correction is found by subtracting from the measured (slant) height S, the quantity S cos a, where a is the vector tilt angle.

It seems to have been shown that Altimeter AN/APN-57, because of its narrow beam, measures slant height rather than vertical height, and that it is therefore necessary to apply a tilt correction. This implies that the attitude of the aircraft must be known, either from bank and climb indicator data, or from some other type of sensing device. However, the application of the tilt correction becomes ineffective for (vector) tilt angles greater than about 3°. It is possible that at angles greater than 3° the reflected signals are too weak to maintain tight control of the servo system.

E. Antenna Pattern Measurements

Measurements of the radiation pattern of Antenna Assembly AS-368/APN-57 were made on 15 and 16 September 1949 with facilities of the Air Force Cambridge Research Laboratories. One object of these measurements was the determination of the effect of tilting the antenna feed off-center. A complete report including graphs is attached as Appendix VIII.

F. Life Test

Two Altimeter AN/APN-57 were selected on 3 July 1951 for purposes of life test. These sets were made up of the following units:

Set No. 1
- RT-125/APN-57 Serial No. 3
- ID-222/APN-57 Serial No. 15

Set No. 2
- RT-125/APN-57 Serial No. 4
- ID-222/APN-57 Serial No. 1

Table I

Summary of Accuracy Test Results, Edwards AFB, March 1950

Run No.	Nominal Altitude, feet	Number of Readings	Vector Tilt Angle, degrees	Tilt Correction, feet	Average Error, Uncorrected, feet	Average Error Corrected for Tilt, feet	Remarks
1	25000	5	2.2	19	65	46	Runs 1 thru 18 made over desert (bombing range) with ballistic cameras
1B	24500	10	2.2	18.5	39.7	21.2	
2A	23500	6	1.4	7.3	62.7	55.4	
3A	24500	1	9.2	317	432	115	
	"	1	7.2	194	305	111	
	"	1	7.8	227	318	91	
	"	1	7.8	227	364	137	
	"	1	7.8	227	416	189	
	"	1	11.4	487	625	138	
	"	1	8.6	278	464	186	
	"	1	6.7	169	359	190	
	"	1	6.7	169	359	190	
	"	1	6.7	169	554	385	
4	24500	9	10	375	1025	650	
5	25000	10	5	95	217	122	
6	25000	10	10	379	427	48	
7	24500	10	3	34	70	36	
8	24500	10	6	134	164	30	
9	24000	10	3	33	68	35	
12	23500	7	0	0	307	307	Antenna feed moved 6° aft

TABLE I, CONT'D.

Run No.	Nominal Altitude, feet	Number of Readings	Vector Tilt Angle, degrees	Tilt Correction, feet	Average Error, Uncorrected, feet	Average Error Corrected for Tilt, feet	Remarks
13	23500	11	0	0	53	53	Antenna feed moved 3° forward
14	23250	10	0	0	95	95	Antenna feed moved 6° forward
15	15500	4	0	0	57	57	
16	15500	10	0	0	39	39	
17A	15500	6	1	2.3	38.3	36	
	"	3	1.4	4.8	52	47	
18	16000	8	0	0	52.5	52.5	
19	16500	2	1.4	5	18	13	Runs 19 and 20 made over dry lake with Askania cameras
	"	4	2	10	31	21	
	"	4	33	2690	3005	315	
	"	1	26	1689	2014	325	
	"	2	32	2530	3118	588	
	"	2	30	2220	2627	407	
	"	1	31	2360	2779	419	
20	16600	2	0	0	9	9	
	"	3	1	2.5	13.3	10.8	
	"	1	2	10	28	18	
	"	1	13	427	473	46	
	"	1	17	728	632	-96	
	"	2	19	905	1035	130	
	"	1	26	1684	1785	101	
	"	1	27	1811	2467	656	
	"	1	28	1950	2089	139	
	"	2	32	2521	2616	95	

Test conditions were established as continuous operation during the normal working day in a +55°C ambient atmosphere and with power input voltages of 29 volts DC and 115 volts 400 cps AC.

Life testing was started on 13 July 1951. Nine serious failures occurred from that time up to 21 July 1951. On the latter date, set No. 1 had run 41.6 hours; set No. 2 had run 48.8 hours. Consideration of this poor performance together with the age of the sets prompted their discard on the basis that they were nearly worn out and life test data obtained on them would be of little value in evaluating the merit of the design.

Two new sets were obtained and put on life test on 2 August. These sets were made up of the following components:

Set No. 3
RT-125/APN-57 Serial No. 12
ID-222/APN-57 Serial No. 13

Set No. 4
RT-125/APN-57 Serial No. 11
ID-222/APN-57 Serial No. 16

These sets were operated until 11 October. During the test period, 230 running hours were accumulated on set No. 3 and 219 running hours on set No. 4. As spare parts had become difficult to get at this time, the tests were terminated. All failures are tabulated in Appendix IX.

During these tests, the most common failure occurred in the modulator unit power supply transformer, T-270. This transformer supplies high voltage to a conventional full-wave rectifier which supplies 35 ma. at 1250 V.

An identical power supply was built on a breadboard and it was found that none of the spare transformers could deliver 27 ma (3/4 load) without burning out. Because of the type contruction used in these components, the internal breakdowns could not be investigated thoroughly. The high surface temperatures reached on these transformers at 75% load indicated improper design. All failures of this component with one exception showed a short-circuited secondary. The one exception had a short from secondary to primary to ground.

The other failures were checked to ascertain whether those component parts, all standard, were being operated within their ratings. With the exception of a slight over-voltage on three tubes, V-423, V-702, and V-350, operating conditions were within the ratings. The exact cause of failure of these standard component parts cannot be ascertained on this quantity of data and the possibility of their being overrated will be studied by the Design Analysis Section of the Aircraft Radiation Laboratory in connection with data being collected on other equipments.

SECTION IV - CONCLUSIONS

It is concluded that:

a. Altimeter AN/APN-57 meets the accuracy requirements specified in the exhibit, provided a compensating error of -42 feet is inserted during calibration, <u>or</u> if 42 feet is subtracted from the altitude readings during data reduction. It is believed that this so-called error arises during the calibration procedure and is not inherent in the altitude measuring circuitry of the equipment. The equipment is calibrated (set to zero) by allowing the main bang to actuate the ranging system. The high power of the main bang causes it to ride past several i-f amplifier stages, arriving at the detector sooner than does the considerably weaker signal from the ground. Further work on the equipment should include an investigation of means of reducing or eliminating this calibration error.

b. The need for antenna stabilization was demonstrated by the apparent increase in indicated altitude caused by banking the test aircraft as little as 3°. Furthermore, tilt correction is not effective for vector tilt angles greater than 3°.

c. The need for a precise, fixed position of the antenna feed was demonstrated during the antenna pattern measurements, when displacing the feed off-center by only 30 minutes of arc caused the antenna beam-width to increase by 35% (from 1.7° to 2.3°).

d. The size of the antenna (60-inch diameter) makes its installation impracticable in any but large aircraft, and even then it is somewhat difficult. Future development of the equipment should include investigation of higher carrier frequencies, which would permit the same or narrower antenna beamwidth to be obtained with a smaller antenna.

e. The few deficiencies revealed by the type test and the number and type of failures experienced in the life test show that the use of Transmitter-Receiver RT-69/APS-10 as a part of Altimeter AN/APN-57, while probably justified from the standpoint of expediency, was not so successful from the standpoint of performance and reliability as a new design would have been.

f. The present system of photographic recording of altitude indications with subsequent data reduction is not desirable. Work is now being conducted on a chart recording attachment for Altimeter AN/APN-57. Although this attachment does not record altitude variations appearing on the error scope, an operational technique proposed by the Photographic Reconnaissance Laboratory subsequent to the design and delivery of Altimeter AN/APN-57, wherein radio altitude readings are taken only over flat and level stretches of terrain, would permit the rapid variations of the error scope indications to be neglected. It is envisaged that the ultimate mapping and charting system would dispense even with the chart recorder, for by the use of digital computer techniques (for example) it is conceivable that radio altitudes, and eventually altitudes above sea level (of the terrain below the mapping aircraft) could be printed in numerical form.

APPENDIX I

CONFERENCE REPORT (Excerpt)

SUBJECT: Vertical Control and Shoran

PLACE: Wright Field, Radar Laboratory

DATE: 3 January 1946

1. A conference was held in Building 150, Wright Field, Dayton, Ohio. Those present were:

Col. Karl L. Polifka, A.C.	311 Recon. Wing, Buckley Field, Colo.
Col. J. F. Setchell, A.C.	311 Recon. Wing, Buckley Field, Colo.
Lt. Col. C.A. Thorpe, A.C.	AC/AS-3, Requirements, Hq. AAF
Lt. Col. C.I. Aslakson, A.C.	311 Recon. Wing, Buckley Field, Colo.
Lt. Col. Philip C. Doran, A.C.	311 Recon. Wing, Buckley Field, Colo.
Maj. F. J. Hickman, A.C.	AC/AS-4, R&D, Hq. AAF
Maj. W. I. Grieve, A.C.	Photo Lab., Eng. Div., Wright Field
Maj. T. W. Barfott, A.C.	311 Recon. Wing, Buckley Field, Colo.
Maj. H. W. Collar, A.C.	Radar Lab., Wright Field
Maj. Harry L. Coggin, A.C.	Aeronautical Chart Service, 36th AAF Base Unit, Washington, D. C.
Maj. Robert H. Kingsley, A.C.	36th AAF Base Unit
Maj. W. T. Latham, A.C.	36th AAF Base Unit
Maj. Elden Sewell, C.E.	Engineer Board, Aerial Photo Br. Wright Field
1st Lt. W.M. Adkisson, S.C.	311 Recon. Wing Buckley Field, Colorado

Capt. J. E. Henry, A.C.	Photo Lab., Wright Field
Capt. A. Zmeskal	Radar Lab., Wright Field
1st Lt. E. C. Evans	Photo Lab., Wright Field
Mr. John Keto	Chief Engineer, Radar Lab.
Mr. N. B. Hogenson	Project Admin. Elec. Subdiv. Wright Field
Mr. Eugene Warnock	Radar Lab., Wright Field
Mr. J. W. McCollister	Photo Lab., Wright Field
Mr. Jack Yolles	Fire Control Br., Radar Lab.
Mr. D. Dingwall	Engineer Board
Mr. S. A. Segen	Fire Control Br., Radar Lab.
Mr. M. Skoller	Fire Control Br., Radar Lab.
Mr. William Dean	Radar Lab., Wright Field

2. Mr. Keto stated that the purpose of the conference was to determine the requirements of the 311th Reconnaissance Wing regarding present and future needs for vertical control in photographic mapping. Colonel Polifka stated that an instrument was needed which would measure altitude accurately to one foot per 1000 feet of altitude. His main objective was to increase the speed of compilations in photographic mapping and insure accurate maps. Present barometric altimeters are not sufficiently accurate. Radiosonde observations are being used in present tests to assist in obtaining altitude readings correct to plus or minus 50 feet. For accurate contour mapping improvements are necessary in both radio and barometric altimeters. A large number of radiosonde stations are necessary for this accuracy.

3. It was decided to state the requirements of the 311th Reconnaissance Wing as:

A. Immediate requirements.

B. Future requirements, final type of equipment needed for accurate mapping.

4. These requirements are summarized below:

A. IMMEDIATE REQUIREMENTS:

(1) <u>Accuracy</u>: In order to prepare satisfactory contour maps, a device is needed to measure the altitude with an accuracy of at least plus or minus one foot per 1000 feet

of altitude. This is a desired objective. However, a minimum accuracy of plus or minus 2 feet per 1000 feet of altitude would be acceptable at the present time. For charting, an accuracy or plus or minus 5 to 8 feet per 1000 feet of altitude would be satisfactory. Radar Laboratory personnel stated that the SCR-718 is accurate to approximately plus or minus 25 feet at any altitude. This meets the contour mapping requirements stated above when the aircraft is flown above 25,000 feet. Because of the relatively broad antenna pattern of the SCR-718, satisfactory observations are possible only over water or flat terrain.

(2) Altitude: In use, such a device would operate from a minimum altitude of 10,000 to a maximum altitude of 35,000 feet. The usual altitude at which this device would be used would be 16,000 to 20,000 feet.

(3) Beam Width: For immediate use, the 311th Reconnaissance Wing agreed to accept an effective beam width of 1.3° since Radar Laboratory stated that the present 60-inch X-Band dish has a beam width of 1.3° and it might be possible to make use of this antenna.

(4) Stabilization: It was desirable that the altimeter antenna be stabilized with the vertical axis of the camera. However, present cameras are not satisfactorily stabilized and it was felt that it would be extremely difficult to stabilize the 60-inch dish. It was decided that a fixed antenna would be acceptable. The antenna would be secured to the aircraft so that the beam would project vertically to the ground when the airplane is in level flight.

(5) Schedule: The first two B-29 control aircraft are to leave in July 1946. It was not expected that vertical control equipment could be installed in these aircraft by that time, although under an emergency development flight test models might be available.

(6) Quantity Requirements: The immediate requirement of the 311th Reconnaissance Wing is 16 equipments, 8 installation and 8 spares.

(7) Indicator: The desired type of indicator is the Marker-Pip type with dials, giving a direct reading as in the AN/APN-3. However, the SCR-718 type of indicator can be flown with scope cameras and would be acceptable. RCA is now developing the APN-42 direct reading altimeter to be flown in July 1946. It may be possible to use such an indicator. It may also be possible to use the Shoran airborne indicator working with the APS-10. These possibilities must be investigated.

B. FUTURE REQUIREMENTS:

The requirements listed below are for equipments to be developed by a long range development program and will give the ultimate desired results for photographic mapping.

(1) Accuracy: Plus or minus one foot for each 2000 feet altitude is desired and plus or minus one foot for each 1000 feet is acceptable.

(2) Altitude: Equipment would be used chiefly from a minimum altitude of 10,000 feet to a maximum altitude of 35,000 feet with the usual altitude being 16,000 to 20,000 feet. If possible, the minimum altitude should be extended to permit observations over high mountains.

(3) Beam Width: The equivalent beam width should be as narrow as possible consistent with associated equipment, or about 0° 5' or less.

(4) Stabilization of Antenna: The antenna should be coupled to the camera such that the vertical axis of the antenna is parallel to the vertical axis of the camera at all times.

(5) Schedule: Future.

(6) Quantity Requirement: Unknown. The Coast and Geodetic Survey, Navy and Army charting and mapping services should be consulted.

(7) Indicator: The exact type of indicator that would best suit the needs of all concerned should be investigated by the Radar Laboratory.

5. Mr. Keto stated that under normal present procedures several months would be required to place a contract for the type of equipment under discussion, provided Hq. AAF granted the necessary authority. This time could be shortened by making this program an emergency procurement.

6. In order to give the best possible accuracy of barometric altimeter readings during the mapping operations, it may be advisable to install radiosonde stations at 200 mile intervals around the area to be photographed. Daily radiosonde readings would permit the making of pressure charts and would correct the barometric altimeter readings.

s/Aldrich Zmeskal
ALDRICH ZMESKAL, Captain, A.C
Radar Laboratory

APPENDIX II

Mr. M. B. Lammers:
ngr:TSTEX: 5-6189

ARMY AIR FORCES
HEADQUARTERS
AIR MATERIEL COMMAND

TECHNICAL INSTRUCTIONS

SERIAL NO.: TI-2204, Addendum No. 1

SUBJECT: System of Vertical Control for Mapping and Charting

TO: Engineering Division

1. Problem Presented:

a. To develop and test a vertical control radio altimeter for mapping and charting, and to procure sixteen (16) equipments, eight (8) of which will be installed in aircraft and the remaining (8) will be used as spares.

2. Factual Data:

a. Project established will cover the development and testing of accurate vertical control equipment which can be used for mapping and aeronautical charting.

b. To assure a near future utilization of such equipment it will be necessary to establish a two-phase developmental program. The first phase will consist of an interim program requirements as established by Inclosure #1 which is attached to the action copy of this TI. The second phase will be a long range program consisting of final type equipment for accurate mapping and charting requirements as established by Inclosure #2 also attached to action copy of this TI.

3. Authority:

a. CG, AAF by 2nd indorsement dated 29 March 1946 from AFDRE-2F/1 to 1st indorsement dated 18 January 1946 from TSELR2A and basic letter dated 19 November 1945, subject: "System of Vertical Control for Mapping and Charting."

4. <u>Action Desired</u>:

a. Engineering Division will:

(1) Establish a development program to accomplish that which is stated in "Problem Presented", as further implemented by "Factual Data".

(2) Procure sixteen (16) sets of equipment.

b. A priority of 1-A is assigned to this project for all phases of this program.

BY COMMAND OF LT. GENERAL TWINING: :

/s/ M. B. Lammers

R. K. TAYLOR
Brigadier General, USA
Chief of Administration

cc: Maintenance Division
Supply Division
Procurement Division
Flight Test Division

IMMEDIATE INTERIM EQUIPMENT

1. Accuracy - In order to prepare satisfactory contour maps, a device is needed to measure the altitude with an accuracy of at least plus or minus one foot per 1000 feet of altitude. This is a desired objective. However, a minimum accuracy of plus or minus 2 feet per 1000 feet of altitude would be acceptable at the present time. For charting, an accuracy of plus or minus 5 to 8 feet per 1000 feet of altitude would be satisfactory.

2. Altitude - In use, the equipment will operate from a minimum altitude of 10,000 feet to a maximum altitude of 30,000 feet. The usual altitude at which this equipment will be used will be approximately 16,000 to 20,000 feet.

3. Beam Width - For immediate use, acceptable effective beam width of 1.3°. It is possible that the 60 inch X-band antenna which has a beam width of 1.3° may be utilized with this equipment.

4. Stabilization - It was desirable that the altimeter antenna be stabilized with the vertical axis of the camera. However, present cameras are not satisfactorily stabilized and it was felt that it would be extremely difficult to stabilize the 60 inch dish. Present cameras are not satisfactorily stabilized; therefore, it may be extremely difficult to stabilize the 60 inch antennae. A fixed antenna will be acceptable. The antenna to be secured to the aircraft so that the beam will project vertically to the ground when the airplane is in level flight.

5. Schedule - The first two B-29 control aircraft are to leave in July 1946. It is not expected that vertical control equipment will be installed in these aircraft by that time, although under an emergency development flight test models might be available.

6. Quantity Requirements - The immediate requirement is for sixteen (16) equipments, eight (8) for installation and eight (8) spares.

7. Indicator - The desired type of indicator is the Marker-Pip type with dials, giving a direct reading as in the AN/APN-3. However, the SCR-718 type of indicator can be flown with scope cameras and would be acceptable. RCA is now developing the APN-42 direct reading altimeter to be flown in July 1946. It may be possible to use such an indicator. It may also be possible to use the Shoran airborne indicator working with the AN/APS-10.

Inclosure #1 [to TI-2204, Add. No. 1]

FINAL EQUIPMENT

The requirements listed below are for equipments to be developed by a long range development program and will give the ultimate desired results for photographic mapping.

1. Accuracy - Plus or minus one foot for each 2000 feet altitude is desired and plus or minus one foot for each 1000 feet is acceptable.

2. Altitude - Equipment to be used primarily from a minimum altitude of 10,000 feet to a maximum altitude of 35,000 feet with the usual altitude being 16,000 to 20,000 feet. If possible, the minimum altitude should be extended to permit observations over high mountains.

3. Beam Width - The equivalent beam width should be as narrow as possible consistent with associated equipment, or about 0° 5' or less.

4. Stabilization of Antenna - The antenna should be coupled to the camera such that the vertical axis of the antenna is parallel to the vertical axis of the camera at all times.

5. Schedule - Future.

6. Quantity Requirement - Unknown

7. Indicator - The exact type of indicator that would best suit the needs of all concerned should be investigated.

Inclosure #2 [to TI-2204, Add. No. 1]

APPENDIX III

Exhibit "A" to CONTRACT W 33-038 ac-15029 — 2 May 1946

DESCRIPTIVE REQUIREMENTS

FOR

VERTICAL CONTROL ALTIMETER EQUIPMENT

A. APPLICABLE SPECIFICATIONS

A-1. The following specifications and drawings of the issue in effect on the date of the request for proposal form a part of this exhibit:

A-1a.	AAF Tentative Specification	71-854	Aircraft Electronic Equipment, General Specification for
A-1b.	Joint Army-Navy	JAN-I-225	Interference Measurement, Radio, Methods of, 150 Kilocycles to 20 Megacycles (for Components and Complete Assemblies)
		JAN-C-172	Cases and Mounting Bases, Radio, Aircraft.

B. TYPES

B-1. The equipment covered by this exhibit consists of the following listed component parts of Vertical Control Altimeter Equipment, each part to be complete except as indicated. Only those parts specifically listed in the contract, and in the quantities therein stated, will be furnished by the contractor.

Part No.	Name and Description
1	Transmitter- Receiver
2	Mounting Base for Transmitter-Receiver
3	Indicator
4	Mounting Base for Indicator
5	Antenna Assembly

B-2. The correct nomenclature for Vertical Control Altimeter Equipment and each of its major components will be supplied to the contractor by the Government as soon as available. The furnished nomenclature must be used on the respective identifying labels, in instruction books, correspondence and at all other times when making reference to the equipment.

C. MATERIAL AND WORKMANSHIP

C-1. This equipment shall comply with the requirements of Section C of AAF Specification No. 71-854 (see paragraph A-1a.), with the following exceptions:

C-1a. Delete references to "Signal Corps Drawing No. SC-D-10381" in Paragraphs C-8 and C-30, AAF Specification No. 71-854 and substitute "JAN-C-172".

D. GENERAL REQUIREMENTS

D-1. This equipment shall comply withthe requirements of Section D of AAF Specification No. 71-854 (see Paragraph A-1a.), with the following exceptions:

D-1a. Delete Paragraph D-1d in its entirety.

D-1b. Delete Paragraph D-1g(1) (a) and substitute the following:

"Conducted Noise. The conducted radio-frequency voltage produced by the operation of this equipment on wiring leading from this equipment to other equipments in the aircraft and between this wiring and ground shall not exceed 50 microvolts over a frequency range of 0.150 to 20 megacycles. The test methods used to determine the extent of radio interference shall be as described in JAN-Specification JAN-I-225 (see paragraph A-1a, above). The contractor shall perform the interference tests and submit the results to the Contracting Officer."

D-1c. Change Paragraph D-2c to read: "Test period shall be thirty days, with the equipment in operation two hours out of each 24."

D-1d. Add a new Paragraph D-7 as follows:

"D-7. Vulnerability to interference. The equipment shall be invulnerable to interference of the types likely to be encountered while installed and in use in military aircraft, to as high a degree as practicable."

D-1e. Delete Paragraph D-2a(3), substitute, "Altitude. - Operation at barometric pressures corresponding to a range of from 10,000 to 35,000 feet altitude above sea-level (sea-level barometer at 30 inches of mercury).

D-2. The Government will furnish the contractor with all Transmitter-Receiver RT-69/APS-10 units for modification, and incorporation into each Vertical Control Altimeter Equipment procured. Other components mentioned in this exhibit will be available to the contractor as stipulated in the contract.

E. DETAIL REQUIREMENTS.

E-1. General. - This exhibit covers a type of high-altitude radio altimeter designed to provide highly accurate readings of distance above terrain by using a narrow antenna beam-width and other necessary refinements. It is intended to replace Radio Set SCR-718-C in a mapping and charting system. Modulator, transmitter, and receiver circuits will be those of Radio Set AN/APS-10, modified; timing and indicating circuits will be those of Radio Set AN/APN-3 (Shoran), suitably modified.

E-2. Range. The range of altitudes through which this equipment will perform shall be from 10,000 to 35,000 feet.

E-3. Accuracy. The error in indications shall not exceed ±0.2 percent. Desired figure is ±0.05 percent.

E-4. Indication. Presentation shall be similar to that of Indicator ID-17/APN-3, utilizing pip-matching and dial or counter reading

E-5. Transmitter-Receiver. The Transmitter-Receiver shall be Transmitter-Receiver RT-69/APS-10, suitably modified by increasing the prf, reducing the pulse width, and increasing the i-f band-width. These modifications shall be made in keeping with the shorter range and greater accuracy required. This unit will be furnished the contractor by the Government.

E-6. Indicator. The Indicator may be similar to Indicator I-152-C (part of Radio Set SCR-718-C), but incorporating necessary features of Indicator ID-17/APN-3 (See paragraph E-4). Size shall not exceed 1.8 cubic feet and weight shall not exceed 60 pounds. All operating controls shall be on the front panel of the indicator unit.

E-7. Antenna. The antenna shall include a parabolic reflector not more than sixty inches in diameter, such that the beam-width at half power does not exceed 1.55 plus or minus 0.1° with the beam centered. The radiated field strength of any of the minor lobes shall be at least 20 db below that of the major (central) lobe. Mounting facilities shall be as nearly identical to those of Antenna Assembly AS-291/APQ as practicable. The antenna assembly need not be stabilized.

E-8. Performance. Performance shall comply with requirements of this Exhibit at all altitudes between 10,000 and 35,000 feet, over all types of terrain, including ice, snow, mountains, and desert.

F. METHODS OF INSPECTION AND TEST

F-1. The requirements of Section F of Specification No. 71-854 are applicable with the exception of Paragraph F-2a, which is deleted.

G. PACKAGING, PACKING, AND MARKING

G-1. See the contract for applicable requirements.

H. NOTES

H-1. Copies of the specifications referenced in paragraph A-1 may be obtained from Commanding General, Air Materiel Command, Wright Field, Dayton, Ohio.

<u>Notice</u>. When government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

APPENDIX IV

TYPE TEST OF ALTIMETER AN/APN-57
By RCA Victor Division. Camden, New Jersey

Spot Temperatures - Unit #1 Specification 71-854-a, paragraph D-1m

Conditions of Test:

1. The points at which temperatures were measured were selected as the hot spots (in terms of component ratings) as determined by tests on an earlier model.

2. Ambient room temperature 26°C. Equipment operated on open bench.

3. Temperatures measured by thermocouples inside dust cover, and thermometers outside dust cover. Temperature rise in transformer windings was determined by calculation from change of resistance in the windings.

4. Duration of test two hours, approximately, sufficient to reach temperature stabilization.

5. Line voltage measured at 120V (High limit) 400 cycles.

6. For first hour servo was balanced on an echo signal. For second hour servo was mechanically tied off balance so that maximum input power to the servo motor was obtained.

	Measured rise above outside ambient temperature	Maximum outside ambient Spec. 71-854-a D-2a, (1)(a)	Expected Maximum temperature of part	Maximum rated temperature of part
Top of Case of Power transformer	39.7	55	94.7	
Filter capacitor near regulator	28	55	83	85
Servo transformer Case	24.9	55	79.9	
Capacitor on Video Amplifier	17.8	55	72.8	85
Multiplier Coil Deflection Chassis	17	55	72	85
Side of case of heater transformer	20.2	55	75.2	

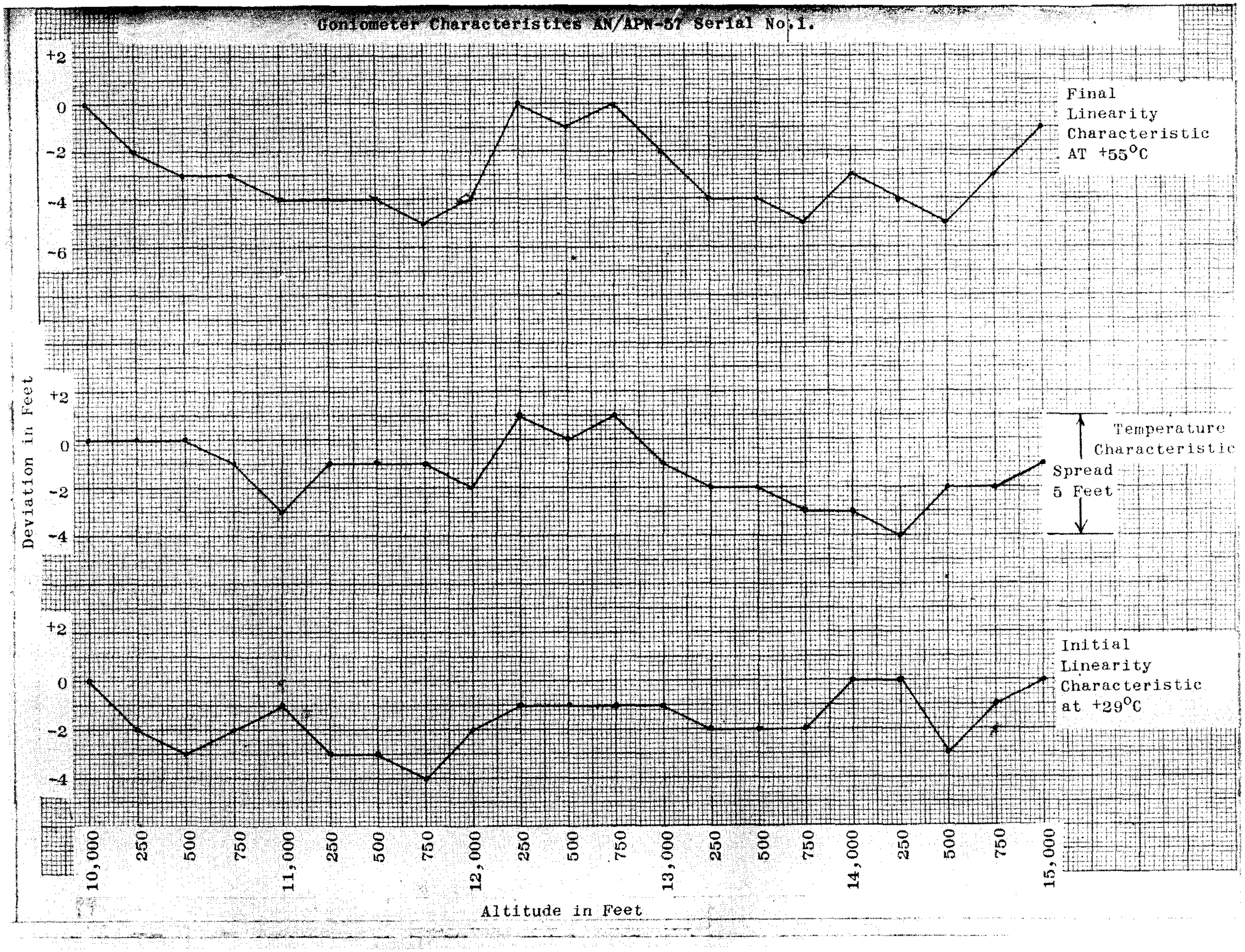


Fig. 12. Goniometer Characteristics AN/APN-57, Serial No. 1

	Measured rise above outside ambient temperature	Maximum outside ambient Spec. 71-854-a D-2a, (1)(a)	Expected Maximum temperature of part	Maximum rated temperature of part
* Heater transformer primary winding	33.5	55	88.5	105
* Servo transformer secondary winding	35.5	55	90.5	105

Equipment Operating (Temperature Test) Unit #1

Specification 71-854-a paragraph D-2a(1)

Purpose:

To determine the effect of temperature on equipment operation, the following were measured over the temperature range -55°C to +71°C:

1. The temperature characteristic of goniometer linearity.
2. The transmitter power output.
3. The receiver sensitivity.
4. The crystal oscillator frequency.
5. The tracking of the 3 KC gate pulse and the 100 KC trigger pulse at the mixer.

Results:-

1. The equipment performed continuously throughout the tests.
2. The servo mechanism goniometer-compensator combination makes one complete revolution for each 5000 feet of altitude so the data was taken only over that range and the information gained applies at each multiple of 5000 feet.
3. If the goniometer compensator were ideally adjusted, the characteristics curves shown on page 32 which were taken at room temperature +29°C would be straight horizontal lines. Also if the goniometer itself were ideal, the characteristic plotted at different temperature, such as +55°C, would also be a straight horizontal line. Then in equipment operation at another temperature any shift in the position of this characteristic straight horizontal line with respect to the one at room

*measured by change in resistance

temperature could be corrected for by putting the "Operate-Calibrate" switch in the "Calibrate" position and adjusting the "zero pulse" knob. After calibration the equipment would give correct indication of altitude.

When these characteristics for room temperature were plotted, the compensator was not ideally adjusted, hence they are not straight horizontal lines, however, since the change of temperature is what we wanted to know from this test, the initial compensator adjustment did not matter. The difference between the curves for different temperatures which actually shows the change of goniometer characteristic for temperature change gives us the limits or spread in error of altitude indication resulting from temperature change.

Ideally in equipment operation the goniometer-compensator would be adjusted so that the characteristic at room temperature would be a straight horizontal (linearity of Unit #1 was adjusted to a spread of 2 feet prior to shipment) line, then at operation at some other temperature, the characteristic to be expected would be the superposition of the temperature characteristic on the straight line. A shift in the average position of the straight line can be corrected for by adjustment of the "zero pulse" knob during equipment calibration. Since the overall characteristic at this other temperature is not flat the limit of inaccuracy is now plus or minus the spread of the temperature characteristic.

If there were no error of altitude indication introduced as a result of temperature change, the temperature characteristics shown on pages pages 32 and 40 would have been straight horizontal lines and the spread zero feet and the inaccuracy would be ± zero feet.

The spread of the temperature characteristic shown on the graph on page 32 is 5 feet resulting from temperature change from 29°C to +55°C.

The spread of the temperature characteristic shown on the graph page 40 is 6 feet resulting from temperature change from +30°C to -53°C.

As a figure of accuracy of these measurements it was found that under the test conditions in reading linearity curves, the curves could be duplicated to within 2 feet or less.

4. The transmitted power unit was measured and found to be constant within 0.3 db (better than the measurement accuracy) over the temperature range of -53°C to +55°C.

5. Receiver sensitivity was very little affected by temperature changes.

6. Notice that receiver sensitivity measurements are all made at the same 10,000 feet altitude position. This is done because the shape of the cyclic pulse is such that below about 7000 feet of altitude the trailing edge of the cyclic pulse will cause readings of A.G.C. voltage which will vary depending upon the altitude at which the measurements are made.

7. The A.G.C. voltage developed is also dependent upon the value of the A.G.C. Delay Voltage at diode V422. This delay voltage varies according to the tolerance of the value of the resistors R527 and R528 and is nominally at +75 to +80 volts.

8. Measurements made on the frequency of the 98 KC crystal oscillator circuit during the temperature tests showed a change of frequency of -3 cps when the temperature changed from 30°C ambient to +55°C ambient and a change of +4 cps when the temperature changed from 30°C to -46°C.

SUBJECT TYPE TEST RUN AT +29°C
Unit Serial No. 1

GONIOMETER LINEARITY

ALTITUDE FEET	DEVIATION IN FEET
15,000	0
750	-1
500	-3
250	0
14,000	0
750	-2
500	-2
250	-2
13,000	-1
750	-1
500	-1
250	-1
12,000	-2
750	-4
500	-3
250	-3
11,000	
750	[illegible]
500	-3
[illegible]	-2
	0

RECEIVER SENSITIVITY
At 10,000 feet altitude

ATTENUATOR READING DB	A.G.C. VOLTAGE Volts
0	-5.1
5	-4.8
10	-4.35
15	-3.65
20	-2.5
25	-0.55
30	0

31 Servo Loses Control

A.G.C. VOLTAGE) ON MAIN BANG) -5.3 VOLTS

MAGNETRON POWER OUTPUT DB

MAGNETRON FREQUENCY MC

SERVO 50 FT OFF TRACKING AT DB

Date April 12, 1948

TYPE TEST RUN AT +55°C
Unit Serial No. 1

GONIOMETER LINEARITY		RECEIVER SENSITIVITY At 10,000 feet altitude	
ALTITUDE FEET	DEVIATION IN FEET	ATTENUATOR READING DB	A.G.C. VOLTAGE Volts
15,000	-1	0	-5.3
750	-3	5	-4.9
500	-5	10	-4.5
250	-4	15	-3.8
14,000	-3	20	-2.75
750	-5	25	-0.9
500	-4	30	0
250	-4	.34 Servo Loses Control	
13,000	-2		
750	0		
500	-1		
250	0		
12,000	-4		
750	-5		
500	-4		
250	-4		
11,000	-4		
750	-3		
500	-3		
250	-2		
10,000	0		

A.G.C. VOLTAGE) -5.3 VOLTS
ON MAIN BANG)

MAGNETRON
POWER OUTPUT DB

MAGNETRON
FREQUENCY MC

SERVO 50 FT
OFF TRACKING AT DB

Date April 12, 1948

TYPE TEST RUN AT +30°C FOR TEMPERATURE CHARACTERISTIC
Unit Serial No. 1

GONIOMETER LINEARITY

ALTITUDE FEET	DEVIATION IN FEET	
15,000	-2	+2
750	-3	-1
500	-3	-1
250	0	+2
14,000	+1	+5
750	-2	+2
500	+1	+3
250	-2	+2
13,000	0	+2
750	-2	+2
500	-1	0
250	-2	+1
12,000	-5	0
750	-3	-1
500	-4	+2
250	-3	+1
11,000	-2	0
750	-3	0
500	-3	-1
250	-2	-1
10,000	0	0

RECEIVER SENSITIVITY
At 10,000 feet altitude

ATTENUATOR READING DB	A.G.C. VOLTAGE Volts (10 V scale)
0	-5.4
5	-5.1
10	-4.7
15	-4.1
	(3 V scale)
20	-3.1, -2.9
25	-1.4
30	0
34	Servo loses control

A.G.C VOLTAGE)
ON MAIN BANG) -5.4 VOLTS

MAGNETRON POWER OUTPUT 12 6 20 38 DB

MAGNETRON FREQUENCY 9347 MC

SERVO 50 FT OFF TRACKING AT DB

Date April 13, 1948

TYPE TEST RUN AT -53°C FOR TEMPERATURE CHARACTERISTIC
Unit Serial No. 1

GONIOMETER LINEARITY

ALTITUDE FEET	DEVIATION IN FEET	
15,000	+3	+1
750	+1	0
500	+2	-2
250	+4	+3
14,000	+5	+3
750	+2	0
500	+4	+2
250	+2	+1
13,000	+2	+1
750	+2	-1
500	+2	-2
250	0	-2
12,000	0	-4
750	-1	-3
500	0	-3
250	+1	0
11,000	+1	-1
750	-1	-1
500	-4	-1
250	-1	-1
10,000	0	0

RECEIVER SENSITIVITY
At 10,000 feet Altitude

ATTENUATOR READING DB	A.G.C VOLTAGE Volts (10 V scale)
0	-5.5
5	-5.0
10	-4.45
15	-3.45
	(3 V scale)
20	-1.8, -1.7
24	0
29 Servo loses control	

A.G.C. VOLTAGE) ON MAIN BANG) -6.0 VOLTS

MAGNETRON POWER OUTPUT 11.7 6.0 20.0 = 37.7 DB

MAGNETRON FREQUENCY 9364 MC

SERVO 50 FT OFF TRACKING AT DB

Date April 14, 1948

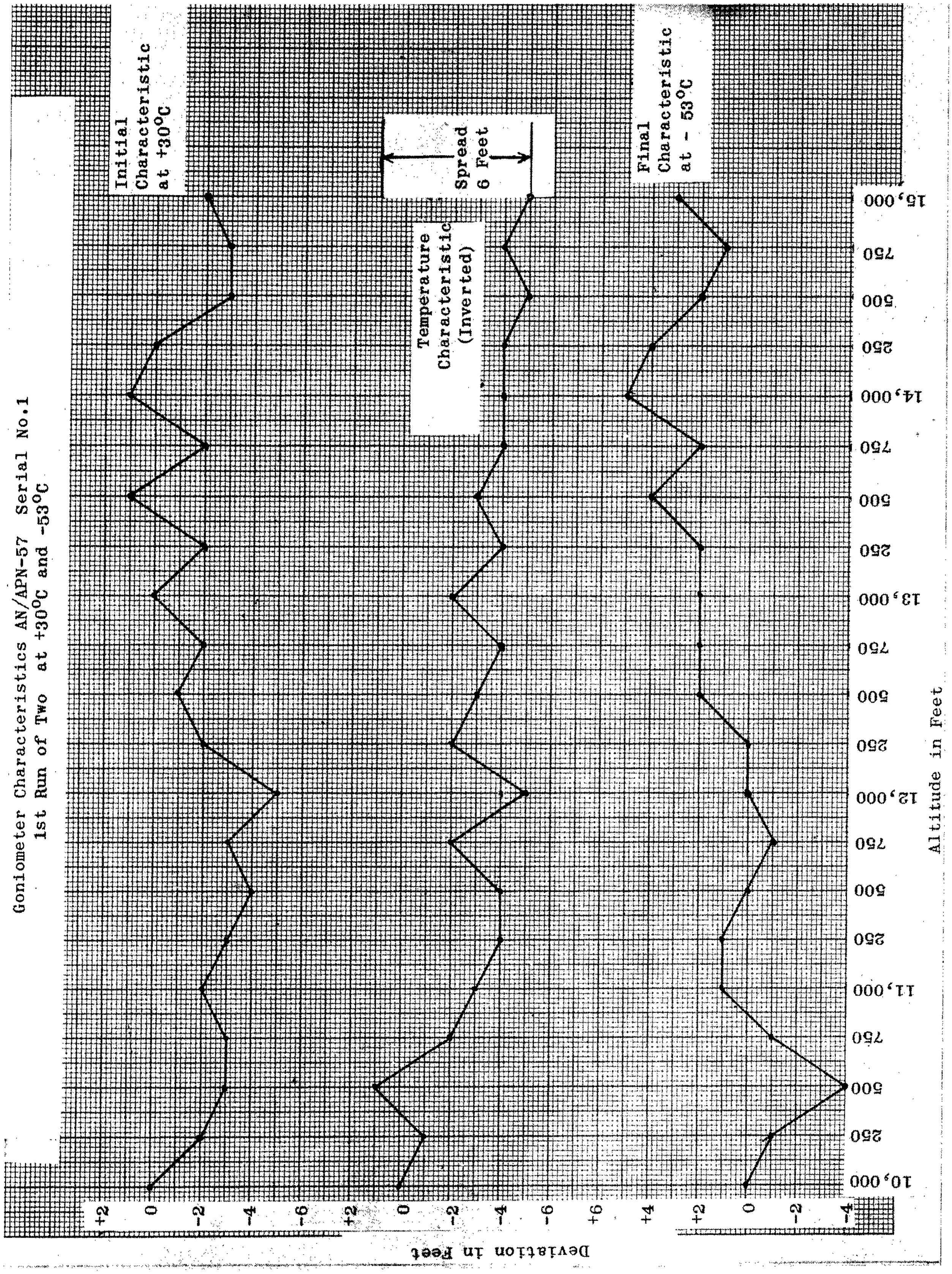


Fig. 13. Goniometer Characteristics AN/APN-57, Serial No. 1

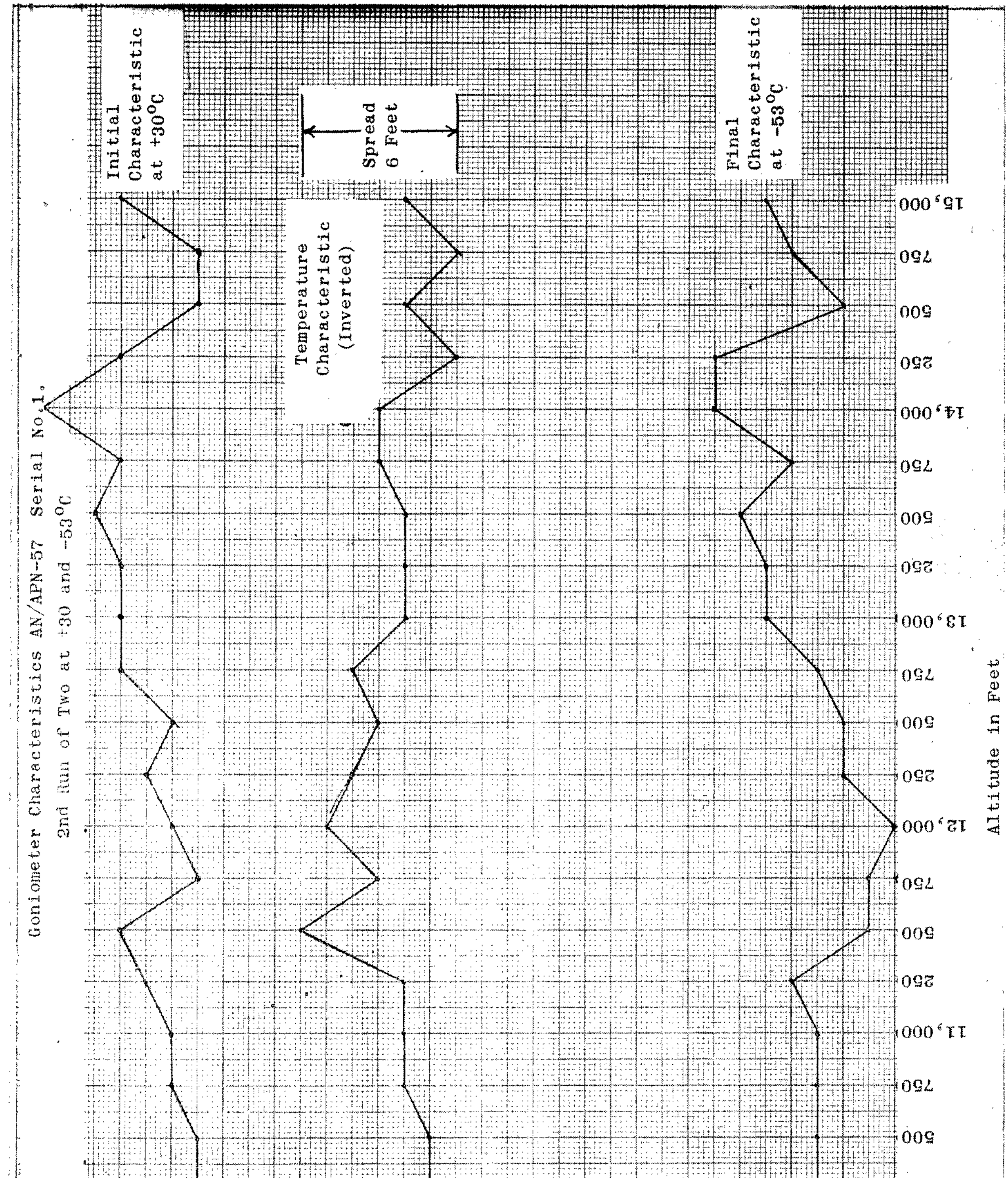


Fig. 14. Goniometer Characteristics AN/APN-57, Serial No. 1

UNIT #1

Measurements made on the mixer pulse at J418 to determine how well the 100 KC pulses tracked in the 3 KC gate pulse, show that as the servo rotates at a fixed temperature the shift of the 100 kc trigger pulses with respect to the gate pulse is less than one microsecond. When the temperature was changed from 30°C ambient to -53°C ambient the trigger pulse however, moved 3 microseconds toward the leading edge of the gate pulse although it stayed close to this position as the servo rotated. This shift was still within safe limits but emphasizes the importance of having the correct alignment adjustment of the trigger pulse centered in the gate when the equipment is operated at room temperature 30°C.

Equipment Operating (Humidity test) Unit #1 - Specification No. 71-854-a paragraph D-2a(2)

Conditions:

1. Equipment in test chamber operated while ambient temperature varied from -55°C to +50°C with 100% humidity.

2. Although condensation took place in and on the equipment in the form of both water and frost, the equipment operated continuously.

3. Detailed data was not taken on this test.

Results:

1. The equipment operated properly all during the tests.

Equipment Operating (Altitude Test) Specified maximum altitude operation 35,000 feet.

Conditions of Test:

1. Equipment in altitude test chamber and operating with ambient temperature 30°C.

2. Chamber evacuated until pressure reached equivalent of 40,000 feet of altitude and remained so for a period of 15 minutes.

Results of Test:

1. Equipment operated continuously and no change in performance was observed.

Equipment Non-Operating (Temperature test) Spec. 71-854-a, paragraph D-2b(1).

Conditions:

1. Equipment set up in chamber and temperature cycled from 30°C to -53°C to +30°C and then turned on and operated.

2. Equipment cycled from 30°C to +85°C and back to +30°C and then turned on and operated.

Results:

1. The equipment operated satisfactorily after subjection to these temperatures and upon further examination no defects were found.

Equipment Non-Operating (Humidity test) Spec. 71-854-a, paragraph D-2h(2)

Conditions:

1. Equipment set up in chamber and operated at room temperature (30°C) and data taken on goniometer linearity, receiver sensitivity, etc.

2. Equipment was then shut off and remained off for a period of 48 hours during which time the temperature of the chamber was maintained at 50°C and the humidity was maintained at 95%.

3. The equipment was then turned on again and more data taken of goniometer linearity and receiver sensitivity.

4. While the equipment continued to operate another set of data was taken one hour later.

5. The equipment was then shut off and remained off while at room conditions of temperature 30°C for a period of 24 hours.

6. The equipment was then turned on again at the end of the 24 hour period and another set of data was taken.

Results:

1. The results of these tests as plotted on the graphs on pages 45 and 49 show that when the equipment is used immediately after storage at high humidity, the spread of goniometer temperature characteristic is as much as 26 feet.

2. The goniometer characteristic measured after 24 hours non-operation had returned to the same as the characteristic measured preceding the test.

3. The characteristic measured after one hour of operation following the storage at 95% humidity and +50°C for 48 hours as compared to the characteristic measured 24 hours later (when after non-operation at room temperature and humidity, the characteristic returned to the same as that measured preceding the test) shows that the spread remaining after the one hour was 15 feet due to the remaining humidity.

4. Other than this change in the characteristic, the equipment operated satisfactorily within 15 minutes after being turned on. Previous to this 15 minutes the trace on the oscilloscope was in bad focus and therefore difficult to read but this was the only fault.

Equipment Non-Operating (Altitude test) Spec. 71-854-a Paragraph D-2b(3)

Conditions:

1. Equipment set up in altitude chamber and with temperature +30°C, barometric altitude was increased to 40,000 feet, maintained at 40,000 feet for a period of 10 minutes, then returned to zero feet of altitude.

Results:

1. The equipment operated satisfactorily after the test and upon examination no defects were observed.

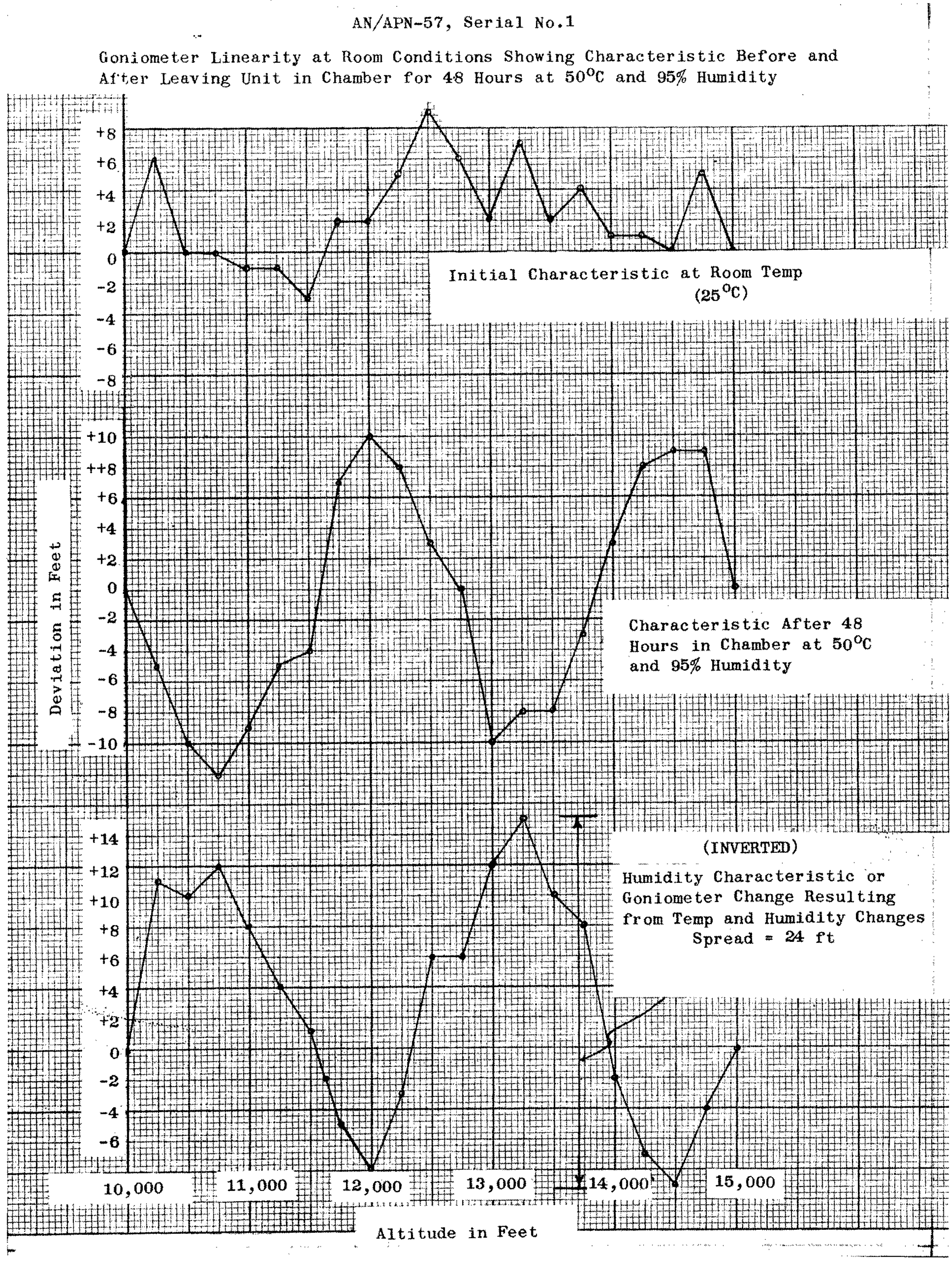


Fig. 15. Goniometer Characteristics, AN/APN-57, Serial No. 1

HUMIDITY TEST
INITIAL CHARACTERISTIC AT ROOM TEMP. (25°C) & HUMIDITY
Unit Serial No. 1

GONIOMETER LINEARITY		RECEIVER SENSITIVITY	
ALTITUDE FEET	DEVIATION IN FEET	ATTENUATOR READING DB	A.G.C. VOLTAGE Volts
15,000	0	0	-4.2
750	+5	5	-3.85
500	0	10	-3.3
250	+1	15	-2.4
14,000	+1	20	-0.95
750	+4	25	-0.05
500	+2	30	-0.05
250	+7	35	-0.05
13,000	+2	39 Servo loses control	
750	+6		
500	+9		
250	+5		
12,000	+2		
750	+2		
500	-3		
250	-1		
11,000	-1		
750	0		
500	0		
250	+6		
10,000	0		

A.G.C. VOLTAGE ON MAIN BANG } -6.5 VOLTS

MAGNETRON POWER OUTPUT 9 / 8 / 19.5 / 36.5 DB

MAGNETRON FREQUENCY 9352 MC

SERVO 50 FT OFF TRACKING AT DB

Date May 18, 1948

HUMIDITY TEST
CHARACTERISTIC AFTER 48 HOURS IN CHAMBER AT 50°C and 95% HUMIDITY
Unit Serial No. 1

GONIOMETER LINEARITY

ALTITUDE FEET	DEVIATION IN FEET
15,000	0
750	+9
500	+9
250	+8
14,000	+3
750	-3
500	-8
250	-8
13,000	-10
750	0
500	+3
250	+8
12,000	+10
750	+7
500	-4
250	-5
11,000	-9
750	-12
500	-10
250	-5
10,000	0

RECEIVER SENSITIVITY

ATTENUATOR READING DB	A.G.C. VOLTAGE Volts
0	-5.5
5	-5.1
10	-4.5
15	-3.5
20	-1.7
22	0
25	+0.4
34.5	+0.4

A.G.C. VOLTAGE ON MAIN BANG	-5.8 VOLTS
MAGNETRON POWER OUTPUT	9 8 19.5 36.5 DB
MAGNETRON FREQUENCY	9353.5 MC
SERVO 50 FT OFF TRACKING AT	27 DB

Date May 20, 1948

HUMIDITY TEST
CHARACTERISTIC OBTAINED ONE HOUR AFTER HUMIDITY TEST
Unit Serial No. 1

GONIOMETER LINEARITY			RECEIVER SENSITIVITY	
ALTITUDE FEET	DEVIATION IN FEET	Temp. Char.	ATTENUATOR READING DB	A.G.C. VOLTAGE Volts
15,000	-1	-1	0	-4.8
750	+6	+1	5	-4.3
500	+3	+3	10	-3.7
250	+4	+3	15	-2.55
14,000	+1	0	20	-0.7
750	-2	-6	21	0
500	-3	-5		
250	-4	-11		
13,000	-8	-10		
750	-1	-7		
500	+5	-4		
250	+8	+3		
12,000	+7	+5		
750	+3	+1		
500	-1	+2		
250	-6	-5		
11,000	-8	-7		
750	-9	-9		
500	-11	-11		
250	-3	-9		
10,000	0	0		

A.G.C. VOLTAGE) ON MAIN BANG) -5.5 VOLTS

MAGNETRON POWER OUTPUT

9
8. DB
19.5
36.5

MAGNETRON FREQUENCY 9353.5 MC

SERVO 50 FT OFF TRACKING AT 27 DB

Date May 20, 1948

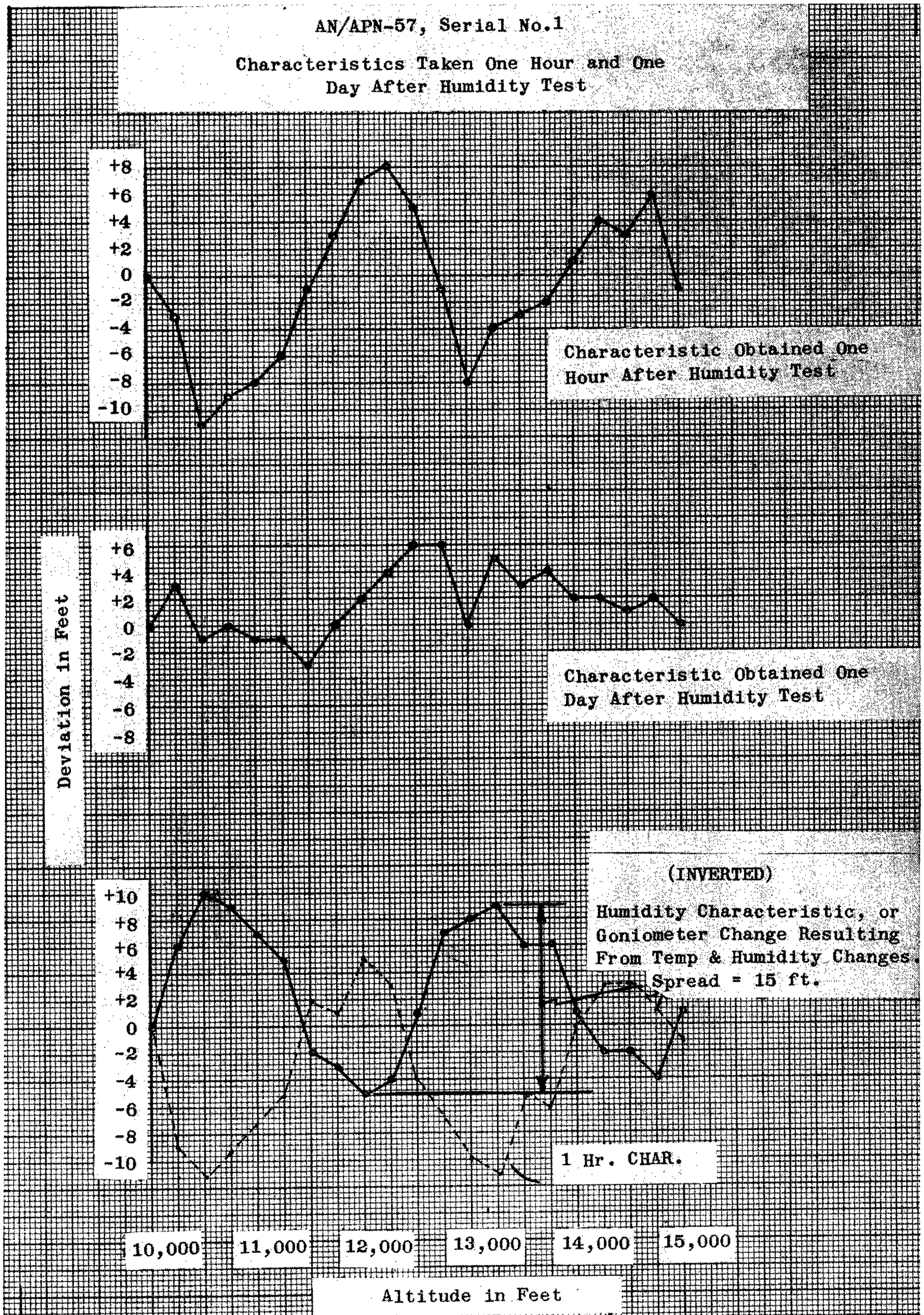


Fig. 16. Goniometer Characteristics, AN/APN-57, Serial No. 1

HUMIDITY TEST
CHARACTERISTIC OBTAINED ONE DAY AFTER HUMIDITY TEST
Unit Serial No. 1

GONIOMETER LINEARITY

ALTITUDE FEET	DEVIATION IN FEET	
15,000	0	0
750	+2	-3
500	+1	+1
250	+2	+1
14,000	+2	+1
750	+4	0
500	+3	+1
250	+5	-2
13,000	0	-2
750	+6	0
500	+6	-3
250	+4	-1
12,000	+2	0
750	0	-2
500	-3	0
250	-1	0
11,000	-1	0
750	0	0
500	-1	-1
250	+3	-3
10,000	0	0

RECEIVER SENSITIVITY

ATTENUATOR READING DB	A.G.C. VOLTAGE Volts
0	-4.55
5	-4.15
10	-3.6
15	-2.7
20	-1.2
24	0
25	

A.G.C. VOLTAGE)
ON MAIN BANG) VOLTS

MAGNETRON
POWER OUTPUT DB

MAGNETRON
FREQUENCY MC

SERVO 50 FT
OFF TRACKING AT 26 DB

Date May 21, 1948

Vibration test - Specification 71-854-a paragraph D-3b

Conditions of test:

1. Equipment mounted on its shock mounts on table and all connections made.

2. Vibration cycled between 10 and 35 cycles/second with an amplitude varying from 1/32" at 10 cycles per second to 3/32" at 35 cycles per second for the first 45 minutes and from 1/32" at 35 cycles per second to 3/32" at 55 cycles per second for the second 45 minutes.

   a. Total of 90 minutes in a direction parallel to the horizontal major axis.

   b. Total of 90 minutes, horizontally at right angles to the major axis.

   c. Total of 90 minutes vertically.

Results of test:

1. Equipment operated continuously during tests except that tube V412 failed (internal grid to cathode short) as table was being changed from crosswise to vertical vibration.

2. With vertical vibration the resonance frequency of the front shock mounts was 10 cycles per second and of the rear shock mounts 14 cycles per second.

Alternating Current Power System Regulation - Specification 71-854-a, Paragraph D-4b(1)(2) and (3)

Conditions:

1. Equipment set up and operated on test bench.

2. Voltage varied from 90 to 135 volts while frequency was set at 300, 400, 500, 600, 700, 800, 900, 1000 cycles per second.

Results:

1. It was found that the indicator would operate satisfactorily over the range 95 to 135 volts; over the whole frequency range 300 to 1000 cycles per second.

2. Below 110 and above 120 volts the A.F.C. circuit in the transmitter receiver unit ceased to operate.

TYPE TESTS ON UNIT #2

The following tests were repeated on Unit #2 with the same results or results as given in the following graphs:

Equipment Operating (Temperature test)

Spread of temperature characteristic 5 ft & 4 ft from +30°C to +55°C

Spread of temperature characteristic 5 ft & 5 ft from +30°C to 0°C

Spread of temperature characteristic 8 ft & 5 ft from +30°C to -55°C

Spread of temperature characteristic 8 ft & 5 ft from +30°C to +71°C

Equipment Operating (Humidity test)

Equipment Operating (Altitude test)

Equipment Non-Operating (Temperature test)

Equipment Non-Operating (Humidity test)

Equipment Non-Operating (Altitude test)

Vibration test

(The equipment operated continuously during the Vibration test)

Alternating Current Power System Regulation.

TYPE TEST FOR TEMPERATURE CHARACTERISTIC +30°C
Unit Serial No. 2

GONIOMETER LINEARITY

ALTITUDE FEET	DEVIATION IN FEET	
15,000	-1	0
750	-1	0
500	-2	-1
250	-2	+1
14,000	0	+1
750	-5	-3
500	-1	-1
250	-1	0
13,000	-1	0
750		
500		
250	-1	0
12,000	-2	-1
750	-2	-2
500	-5	-3
250	-2	-2
11,000	-2	-1
750	-1	-1
500	0	0
250	0	0
10,000	0	0

RECEIVER SENSITIVITY
At 10,000 feet altitude

ATTENUATOR READING DB	A.G.C. VOLTAGE Volts
0	-4
5	-3.7
10	-3.5
15	-2.8
20	-2.3
25	-1.35
30	-.55

A.G.C. VOLTAGE ON MAIN BANG	-4.7	VOLTS
MAGNETRON POWER OUTPUT	20 4 9.5 33.5	DB
MAGNETRON FREQUENCY	9336	MC
SERVO 50 FT OFF TRACKING AT	31	DB

Date August 27, 1948

TYPE TEST TEMPERATURE CHARACTERISTIC +55°C
Unit Serial No. 2

GONIOMETER LINEARITY

ALTITUDE FEET	DEVIATION IN FEET 1st Run	2nd Run
15,000	-1	-2
750	-3	-3
500	-3	-3
250	-1	-3
14,000	-3	-3
750	-3	-4
500	-3	-3
250	-3	-3
13,000		
750		
500	-2	-3
250	-4	-4
12,000	-5	-5
750	-5	-6
500	-5	-6
250	-4	-5
11,000	-4	-3
750	-4	-3
500	-2	-3
250	-1	-2
10,000	0	0

RECEIVER SENSITIVITY
At 10,000 feet altitude

ATTENUATOR READING DB	A.G.C. VOLTAGE Volts
0	3.4
5	3.1, 2.9 (3 V scale)
10	2.6
15	2.15
20	1.55
25	.55
30	.1

A.G.C. VOLTAGE ON MAIN BANG: 3.8 VOLTS

MAGNETRON POWER OUTPUT: 20 + 4 + 9 = 33 DB

MAGNETRON FREQUENCY: 9332 MC

SERVO 50 FT OFF TRACKING AT: 31 DB

Date August 30, 1948

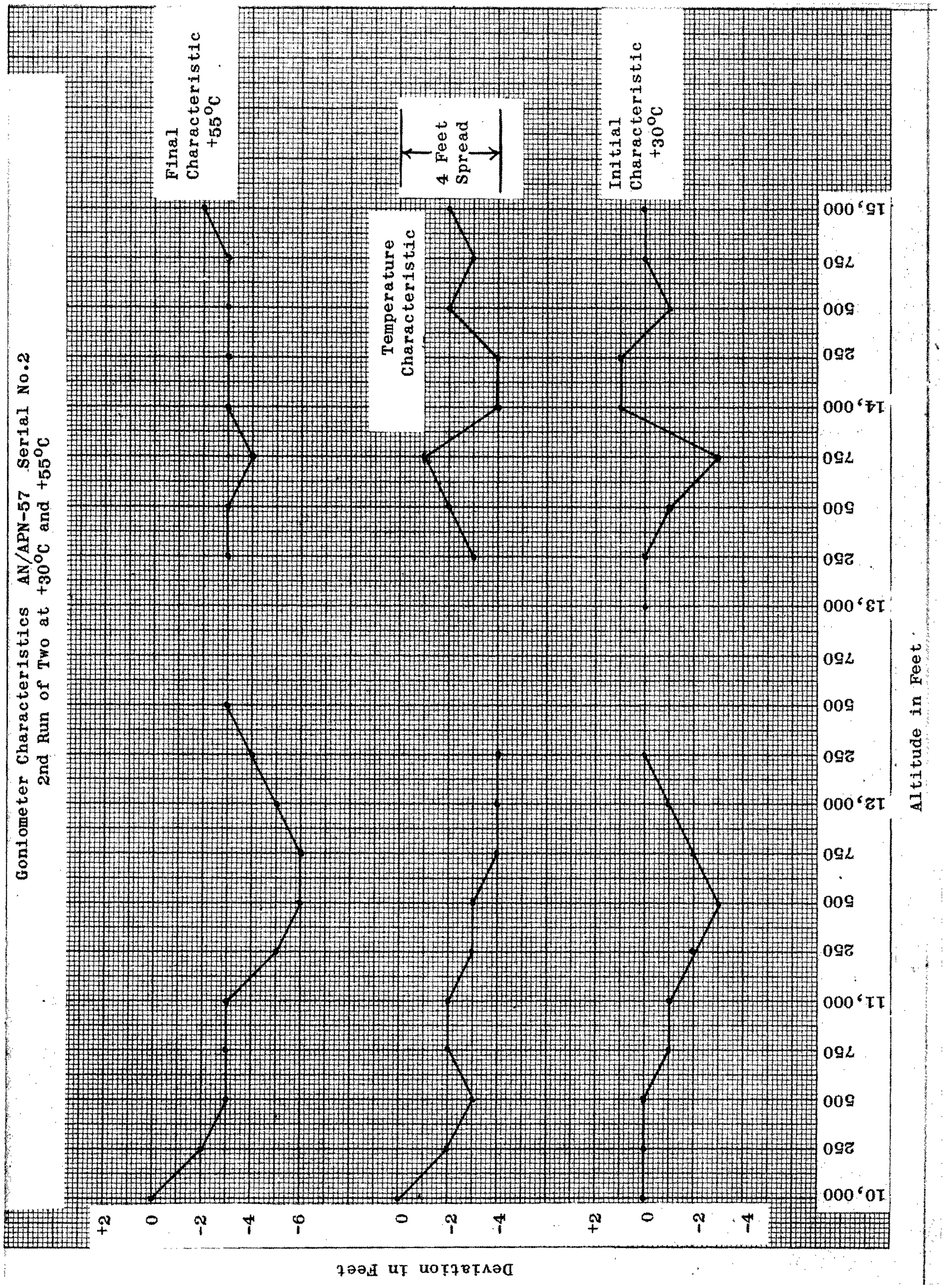


Fig. 17. Goniometer Characteristics, AN/APN-57, Serial No. 2

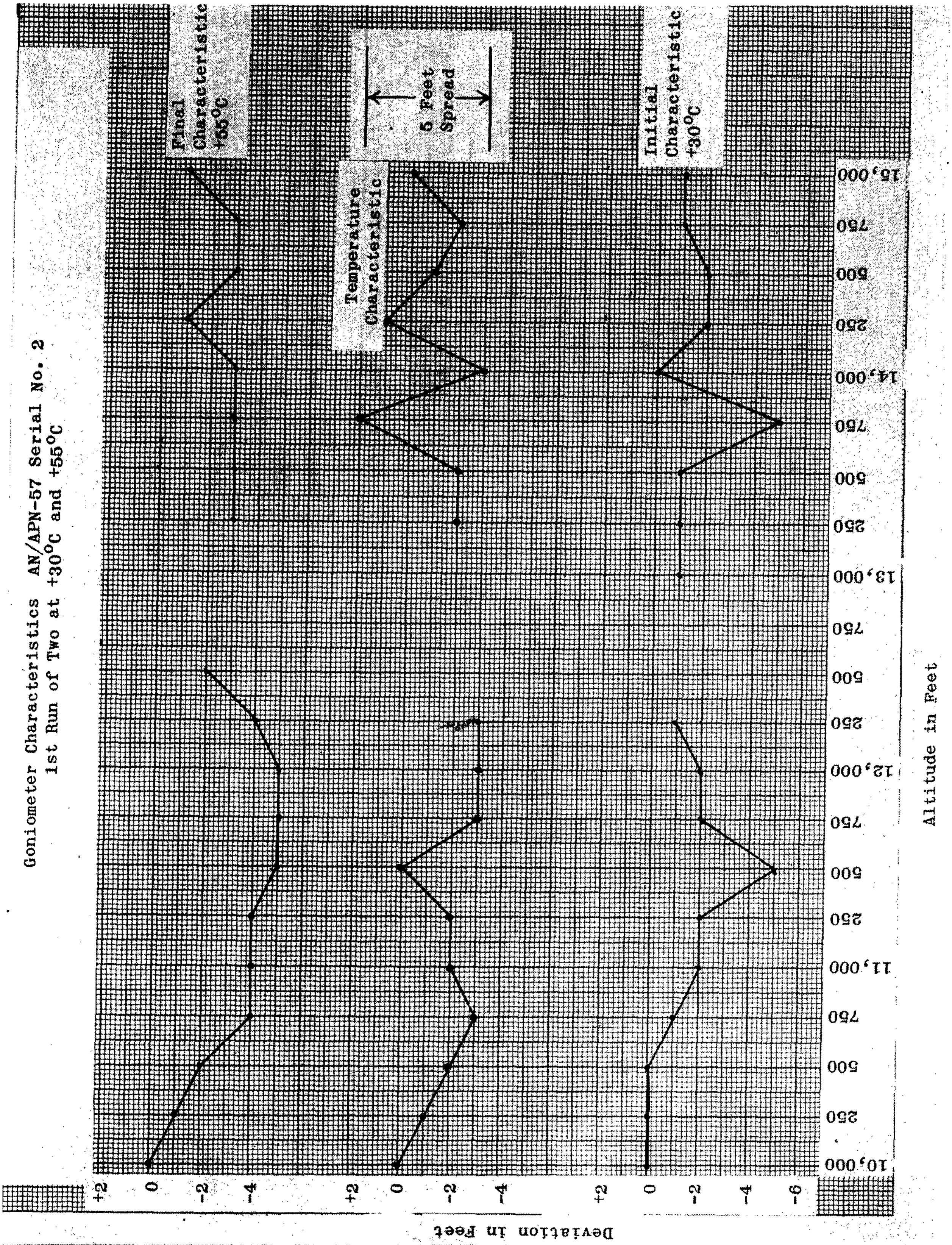


Fig. 18. Goniometer Characteristics, AN/APN-57, Serial No.

TEMPERATURE TEST
EQUIPMENT OPERATING IN CHAMBER AT +30°C
Unit Serial No. 2

GONIOMETER LINEARITY

ALTITUDE FEET	DEVIATION IN FEET 1st Run	2nd Run
15,000	-1	0
750	-1	0
500	-2	-1
250	-2	+1
14,000	0	+1
750	-5	-3
500	-1	-1
250	-1	0
13,000	-1	0
750		
500		
250	-1	0
12,000	-2	-1
750	-2	-2
500	-5	-3
250	-2	-2
11,000	-2	-1
750	-1	-1
500	0	0
250	0	0
10,000	0	0

RECEIVER SENSITIVITY

ATTENUATOR READING DB	A.G.C. VOLTAGE Volts
0	-4
5	-3.7
10	-3.5
15	-2.8
20	-2.3
25	-1.35
30	-0.55

A.G.C. VOLTAGE ON MAIN BANG: -4.7 VOLTS

MAGNETRON POWER OUTPUT: 9.5 + 4.0 + 20.0 = 33.5 DB

MAGNETRON FREQUENCY: 9336.5 MC

SERVO 50 FT OFF TRACKING AT: 31 DB

Date August 27, 1948

TEMPERATURE TEST
EQUIPMENT OPERATING IN CHAMBER AT 0°C
Unit Serial No. 2

GONIOMETER LINEARITY

ALTITUDE FEET	DEVIATION IN FEET 1st Run	2nd Run
15,000	+3	0
750	+2	0
500	+2	-1
250	+3	-1
14,000	+2	0
750	+2	0
500	+2	-1
250		
13,000		
750		
500	+2	0
250	0	-1
12,000	+1	-1
750	0	-2
500	-1	-2
250	+2	-1
11,000	+3	-1
750	+2	0
500	0	-2
250	0	-1
10,000	0	0

RECEIVER SENSITIVITY

ATTENUATOR READING DB	A.G.C. VOLTAGE Volts
0	-3.4
5	-3.0, -2.9
10	-2.6
15	-2.15
20	-1.55
25	-0.65
30	-0.10
35	

A.G.C. VOLTAGE ON MAIN BANG) -3.9 VOLTS

MAGNETRON POWER OUTPUT
9
4 DB
20
33

MAGNETRON FREQUENCY 9342 MC

SERVO 50 FT OFF TRACKING AT 31 DB

Date August 30, 1948

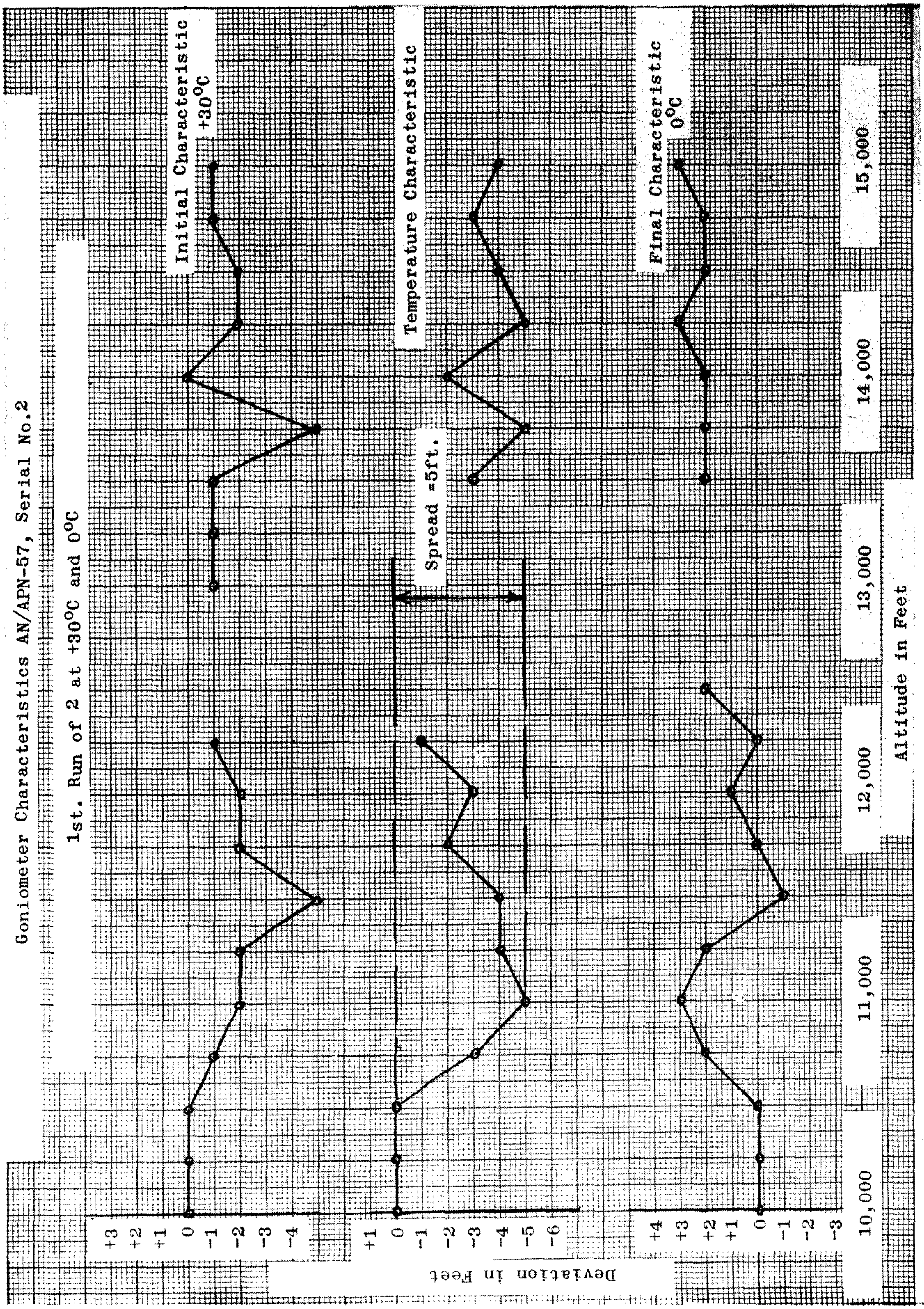


Fig. 19. Goniometer Characteristics, AN/APN-57, Serial No. 2

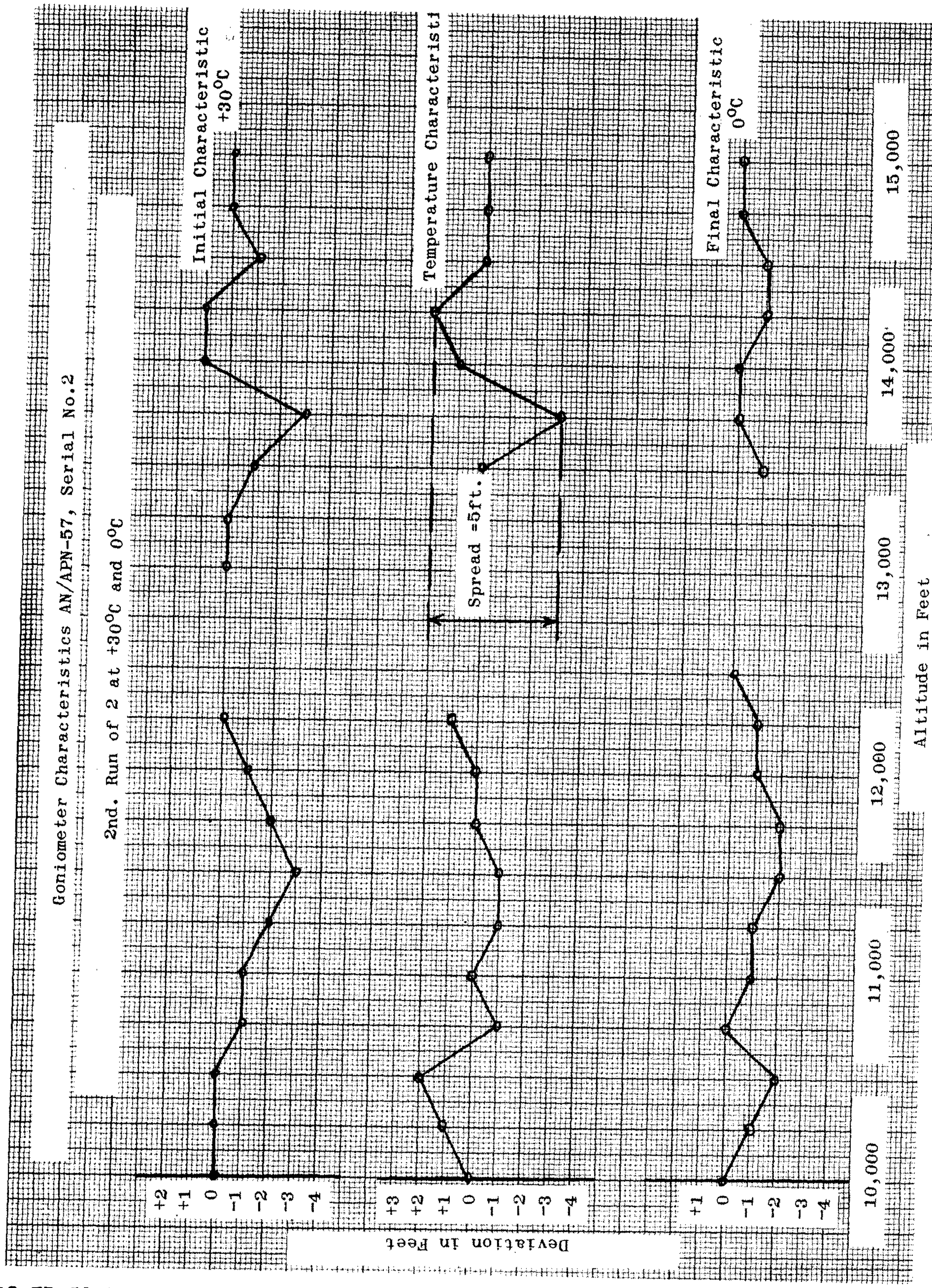


Fig. 20. Goniometer Characteristics, AN/APN-57, Serial No. 2

TEMPERATURE TESTS
EQUIPMENT OPERATING IN CHAMBER AT +30°C
Unit Serial No. 2

GONIOMETER LINEARITY

ALTITUDE FEET	DEVIATION IN FEET 1st Run	2nd Run	3rd Run
15,000	+2	0	+1
750	+1	-1	0
500	+1	-1	0
250	+2	+1	+1
14,000	+2	+2	+1
750	+2	0	0
500	+1	-1	-1
250	+2	+1	0
13,000	+2	+1	+2
750	+1	-1	0
500	0	-2	-1
250			
12,000			
750	0	-2	-1
500	-1	-2	-3
250	-1	-2	-2
11,000	-1	-1	-2
750	-2	-2	-3
500	-1	-2	-2
250	-1	-2	-1
10,000	0	-1	0

RECEIVER SENSITIVITY

ATTENUATOR READING DB	A.G.C. VOLTAGE Volts
0	-2.6
5	-2.3
10	-1.8
15	-1.2
20	-0.1
25	-0.1

A.G.C. VOLTAGE ON MAIN BANG) -3.3 VOLTS

MAGNETRON POWER OUTPUT 10 + 4 + 20 = 34 DB

MAGNETRON FREQUENCY 9333.5 MC

SERVO 50 FT OFF TRACKING AT 27 DB

Date September 1, 1948

TEMPERATURE TESTS
EQUIPMENT OPERATING IN CHAMBER AT +71°C
Unit Serial No. 2

GONIOMETER LINEARITY

ALTITUDE FEET	DEVIATION IN FEET
15,000	+1
750	-1
500	-1
250	-1
14,000	-2
750	-3
500	-3
250	
13,000	
750	-3
500	-3
250	-3
12,000	-2
750	-2
500	-3
250	-2
11,000	0
750	0
500	0
250	
10,000	

RECEIVER SENSITIVITY

ATTENUATOR READING DB	A.G.C. VOLTAGE Volts
0	-3.4
5	-3.0, -2.8
10	-2.5
15	-2.0
20	-1.3
25	0

A.G.C. VOLTAGE ON MAIN BANG	-3.6 VOLTS	
MAGNETRON POWER OUTPUT	10 4 20 34	DB
MAGNETRON FREQUENCY	9329	MC
SERVO 50 FT OFF TRACKING AT	29	DB

Date August 31, 1948

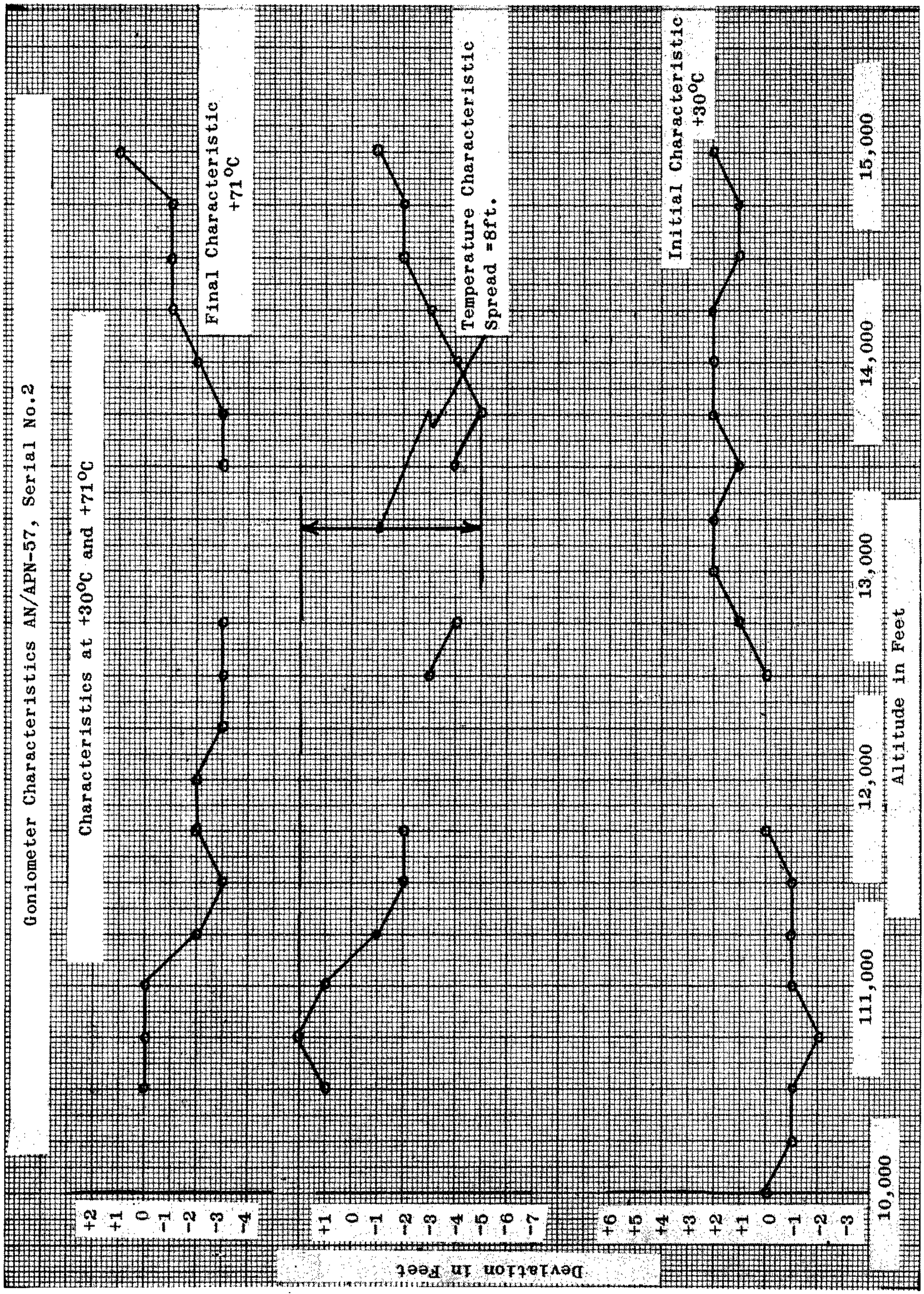


Fig. 21. Goniometer Characteristics, AN/APN-57, Serial No. 2

TYPE TEST RUN AT +30°C FOR TEMPERATURE CHARACTERISTIC
Unit Serial No. 2

GONIOMETER LINEARITY			RECEIVER SENSITIVITY At 10,000 feet altitude	
ALTITUDE FEET	DEVIATION IN FEET 1st Run	2nd Run	ATTENUATOR READING DB	A.G.C VOLTAGE Volts
15,000	-1	0	0	-4
750	-1	0	5	-3.7
500	-2	-1	10	-3.5
250	-2	+1	15	-2.8
14,000	0	+1	20	-2.3
750	-5	-3	25	-1.35
500	-1	-1	30	-.55
250	-1	0		
13,000	-1	0		
750				
500				
250	-1	0		
12,000	-2	-1		
750	-2	-2		
500	-5	-3		
250	-2	-2		
11,000	-2	-1		
750	-1	-1		
500	0	0		
250	0	0		
10,000	0	0		

A.G.C. VOLTAGE) ON MAIN BANG) -4.7 VOLTS

MAGNETRON POWER OUTPUT 20 + 4 + 9.5 = 33.5 DB

MAGNETRON FREQUENCY 9336 MC

SERVO 50 FT OFF TRACKING AT 31 DB

Date August 27, 1948

TYPE TEST RUN AT -55°C FOR TEMPERATURE CHARACTERISTIC
Unit Serial No. 2

GONIOMETER LINEARITY

ALTITUDE FEET	DEVIATION IN FEET 1st Run	2nd Run
15,000	+2	+2
750	+1	0
500	+1	+1
250	0	+1
14,000	+2	+2
750	+1	+1
500	+1	+1
250	+2	+2
13,000	+2	+2
750		+1
500		
250		
12,000	0	0
750	-1	-1
500	-2	-1
250	-2	-1
11,000	-1	0
750	-3	-1
500	-2	-1
250	0	0
10,000	0	0

RECEIVER SENSITIVITY
At 10,000 feet altitude

ATTENUATOR READING DB	A.G.C. VOLTAGE Volts
0	-2.9
5	-2.65
10	-2.25
15	1.7
20	1.0
25	-0.05
30	00
35	00

A.G.C. VOLTAGE ON MAIN BANG		VOLTS
MAGNETRON POWER OUTPUT	20 4 8 32	DB
MAGNETRON FREQUENCY	9348	MC
SERVO 50 FT OFF TRACKING AT	28	DB

Date September 1, 1948

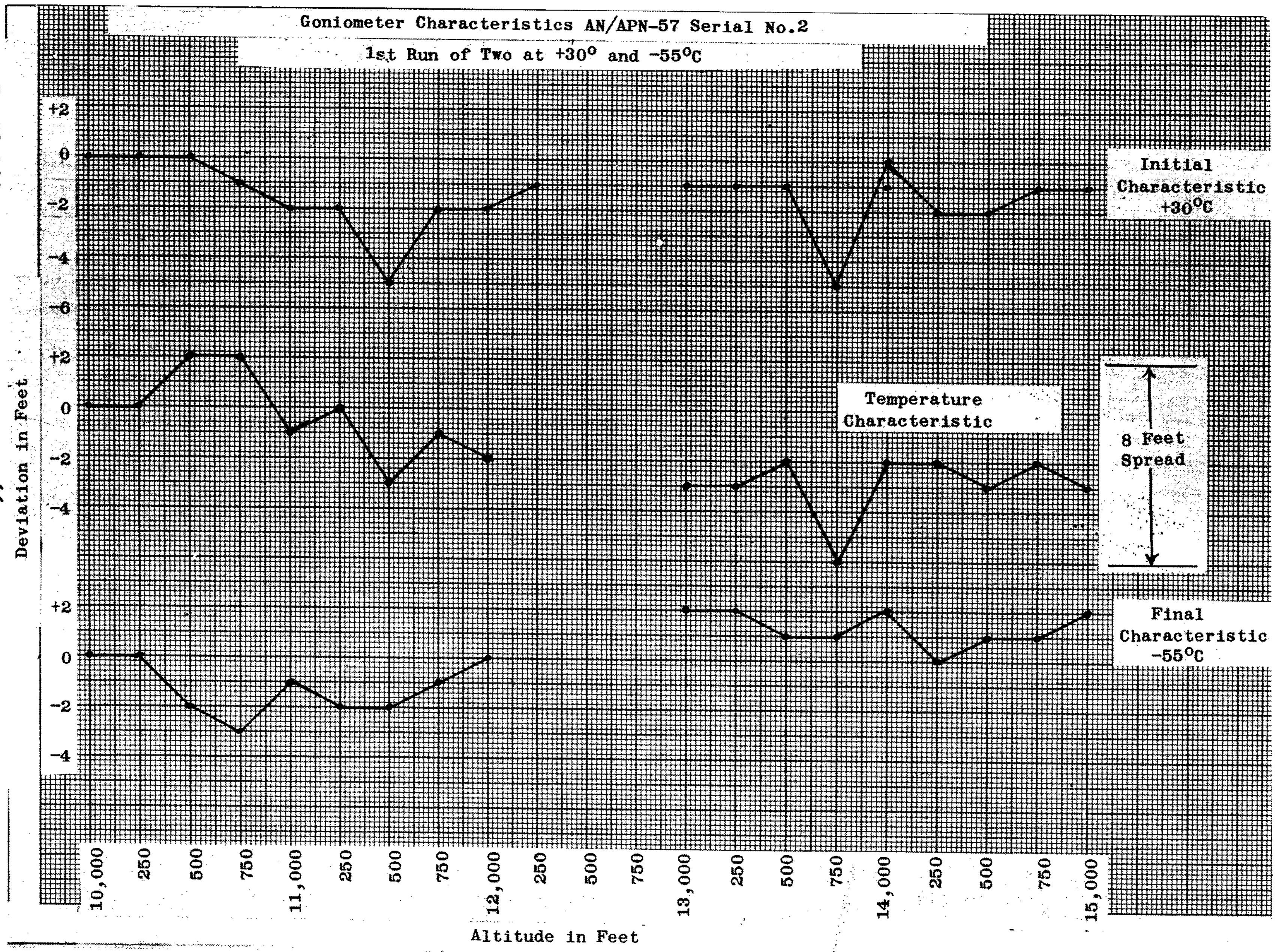
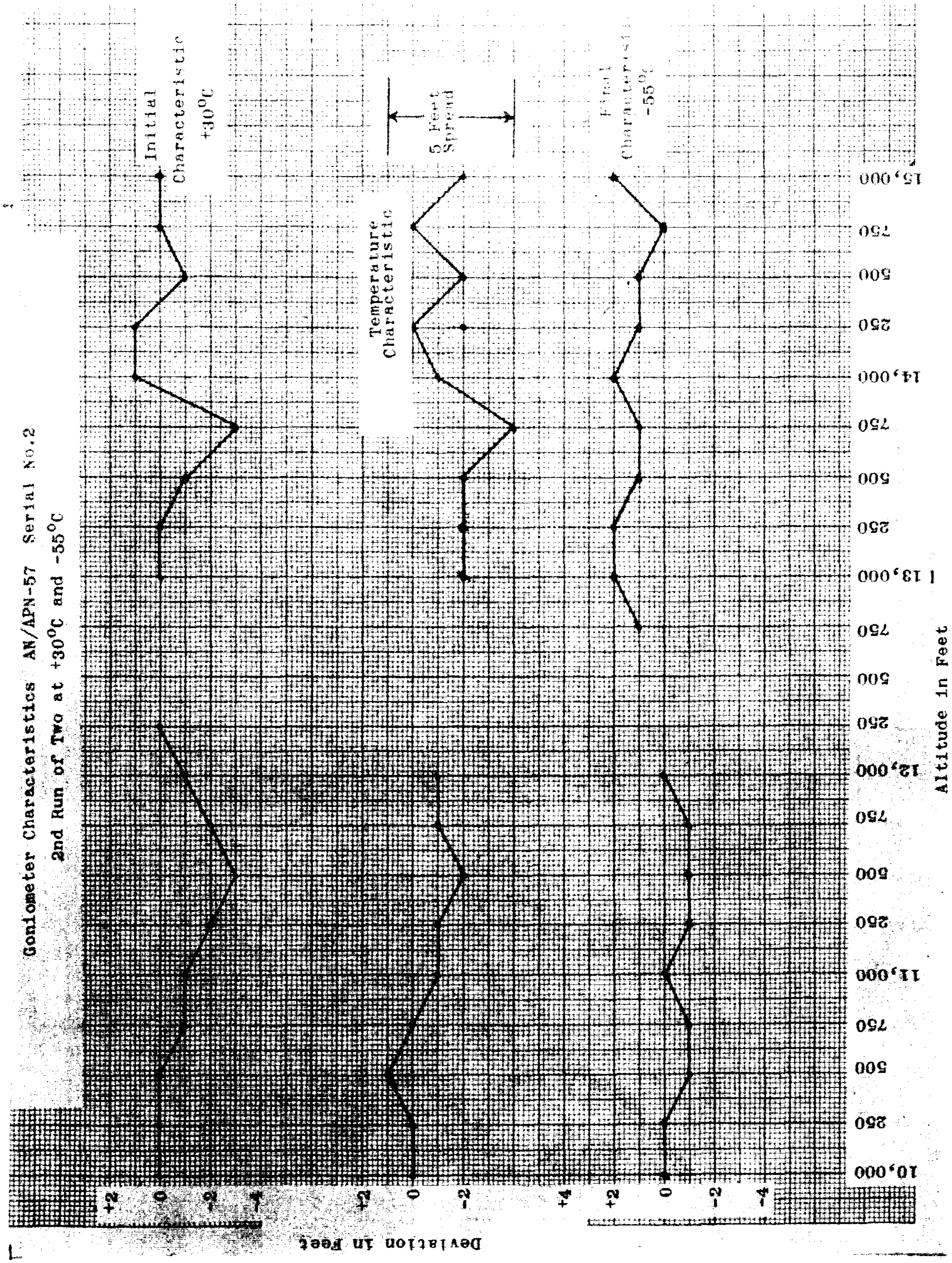


Fig. 22. Goniometer Characteristics, AN/APN-57, Serial No. 2



Goniometer Characteristics AN/APN-57 Serial No.2
2nd Run of Two at +30°C and -55°C
Initial Characteristic +30°C
Temperature Characteristic
5 Feet Spread
Final Characteristic -55°C
Altitude in Feet
Deviation in Feet
10,000 250 500 750 11,000 250 500 750 12,000 250 500 750 13,000 250 500 750 14,000 250 500 750 15,000
+2 0 -2 -4

HUMIDITY TEST AN/APN-57
GONIOMETER CHARACTERISTICS TAKEN AT ROOM CONDITIONS
IMMEDIATELY BEFORE HUMIDITY TEST
Serial No. 2

GONIOMETER LINEARITY

ALTITUDE FEET	DEVIATION IN FEET Char. Plotted			
15,000	-2	0	+1	+1
750	-3	0	0	-1
500	-3	0	0	-1
250	-4	-1	0	-2
14,000	-4	-2	-2	-2
750	-5	-4	-2	-3
500	-4	-4	-1	-2
250			-1	
13,000				
750				
500	-4	-1	+2	-1
250	-5	-3	+2	-3
12,000	-5	-4	0	-4
750	-10	-11	-4	-11
500	-10	-13	-5	-11
250	-10	-9	-3	-9
11,000	-8	-7	0	-8
750	-9	-8	-1	-5
500	-7	-6	+1	-2
250	-5	-3	0	-1
10,000	0	0	0	0

RECEIVER SENSITIVITY

ATTENUATOR READING DB	A.G.C. VOLTAGE Volts
0	-3.5
5	-3.1, -2.9
10	-2.5
15	-2.0
20	-1.3
25	-0.25
30	00

A.G.C. VOLTAGE ON MAIN BANG	-3.5 VOLTS
MAGNETRON POWER OUTPUT	12 4 20 36 DB
MAGNETRON FREQUENCY	9353 MC
SERVO 50 FT OFF TRACKING AT	32 DB

Date September 24, 1948

HUMIDITY TEST AN/APN-57
GONIOMETER CHARACTERISTICS TAKEN AT VARIOUS TIMES AFTER UNIT WAS LEFT IN CHAMBER FOR 66 HOURS AT 50°C and 100% HUMIDITY

GONIOMETER LINEARITY

ALTITUDE FEET	DEVIATION IN FEET Immed. after test	1 hr. aft. test	6 hr. aft. test
15,000	-4	-1	+2
750	-3	-6	0
500	-6	-6	-2
250	-13	-8	-2
14,000	-22	-16	-6
750	-28	-21	-7
500	-24	-18	-10
250			-10
13,000			-10
750			-2
500	-3	0	0
250	-6	-1	-2
12,000	-10	-6	-3
750	-23	-16	-10
500	-28	-18	-10
250	-28	-21	-9
11,000	-28	-24	-10
750	-26	-19	-8
500	-18	-13	-5
250	-8	-8	0
10,000	0	0	0

RECEIVER SENSITIVITY

ATTENUATOR READING DB	A.G.C VOLTAGE Volts
0	-4.0
5	-3.7
10	-3.2, -3.0
15	-2.45
20	-1.6
25	-0.2
30	00

A.G.C. VOLTAGE) ON MAIN BANG)	-4.4	VOLTS
MAGNETRON POWER OUTPUT	12 4 20 36	DB
MAGNETRON FREQUENCY	9353	MC
SERVO 50 FT OFF TRACKING AT	31	DB

Date September 27, 1948

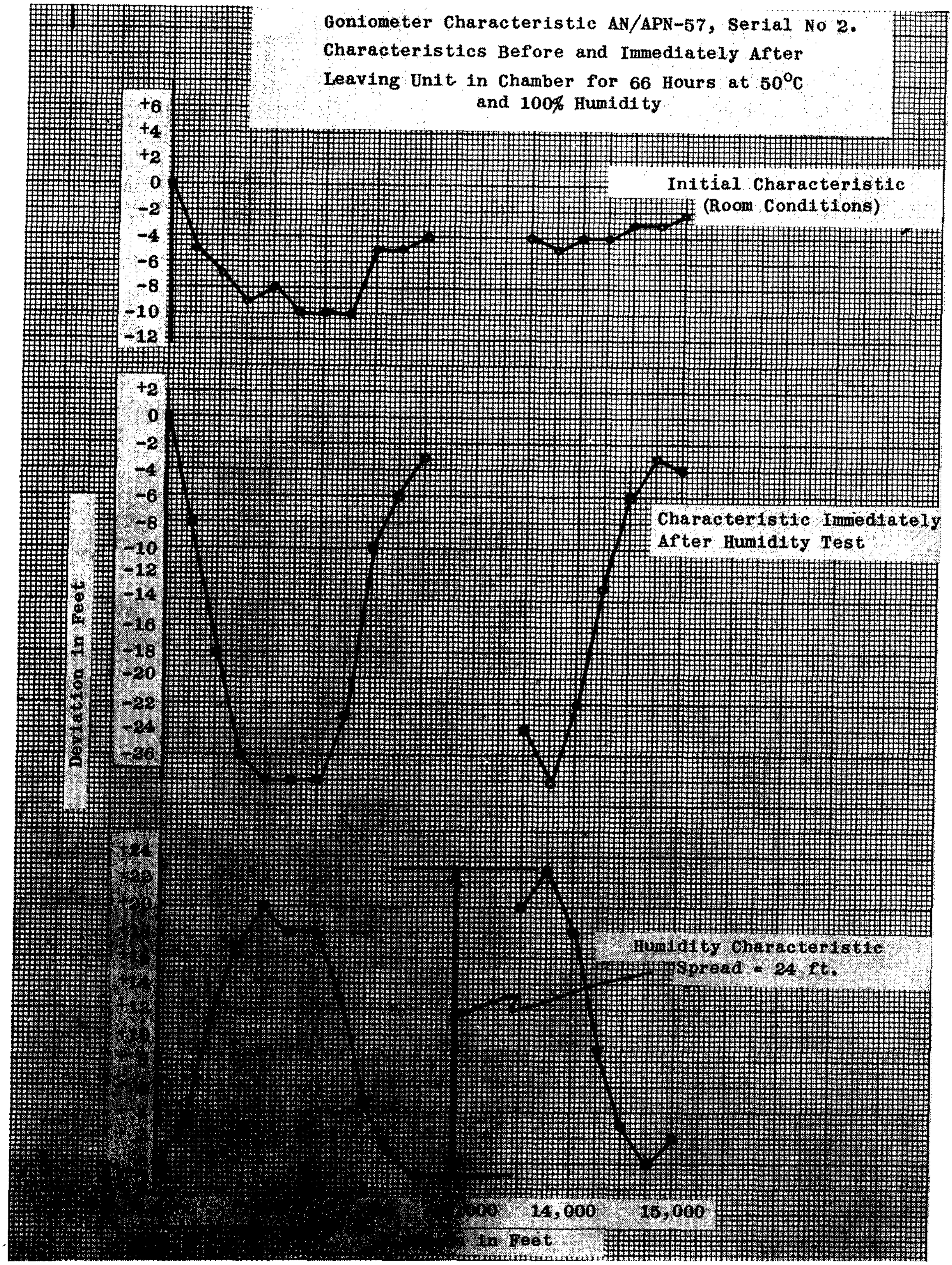


Fig. 24. Goniometer Characteristics, AN/APN-57, Serial No. 2

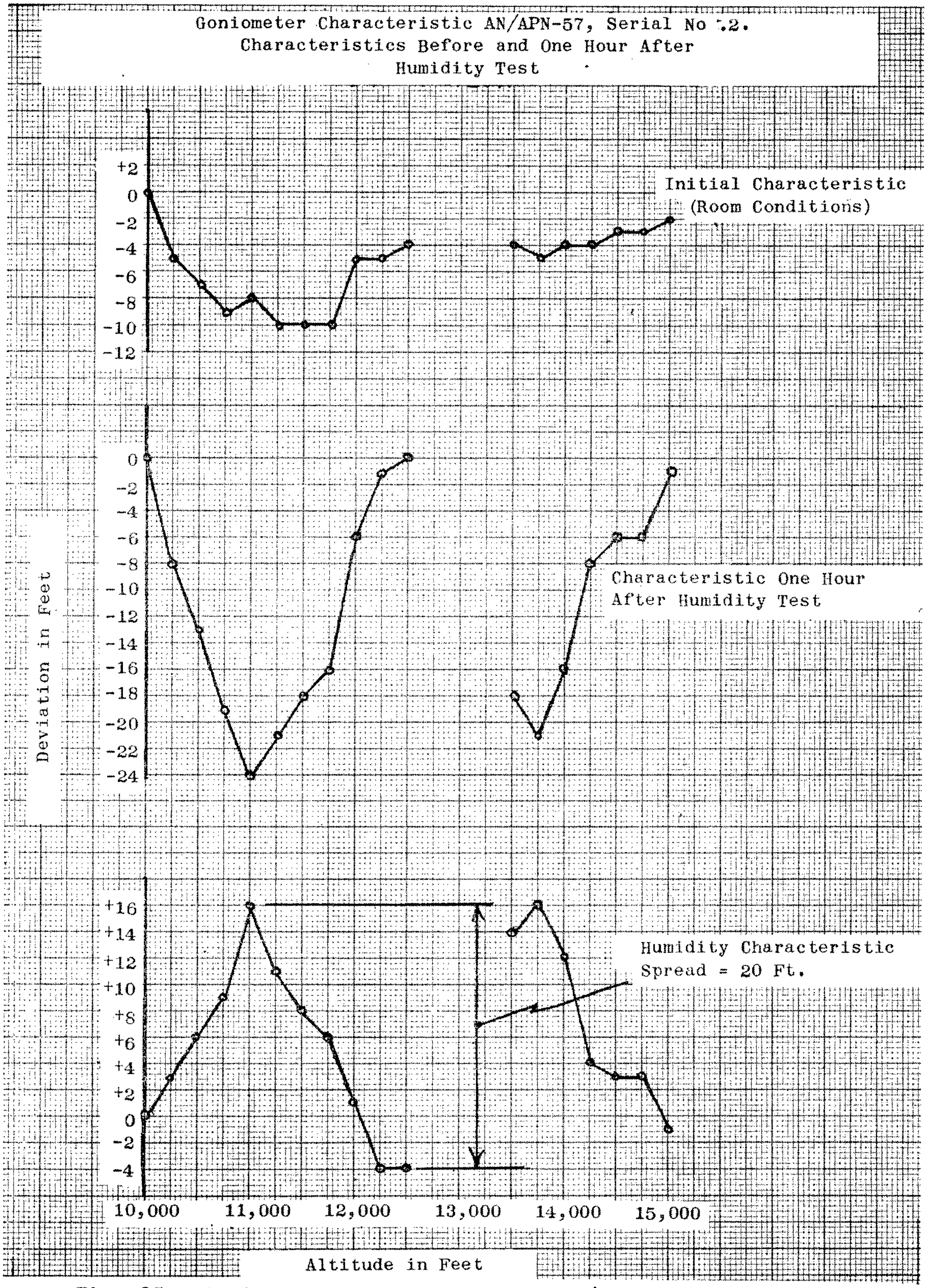


Fig. 25. Goniometer Characteristics, AN/APN-57, Serial No. 2

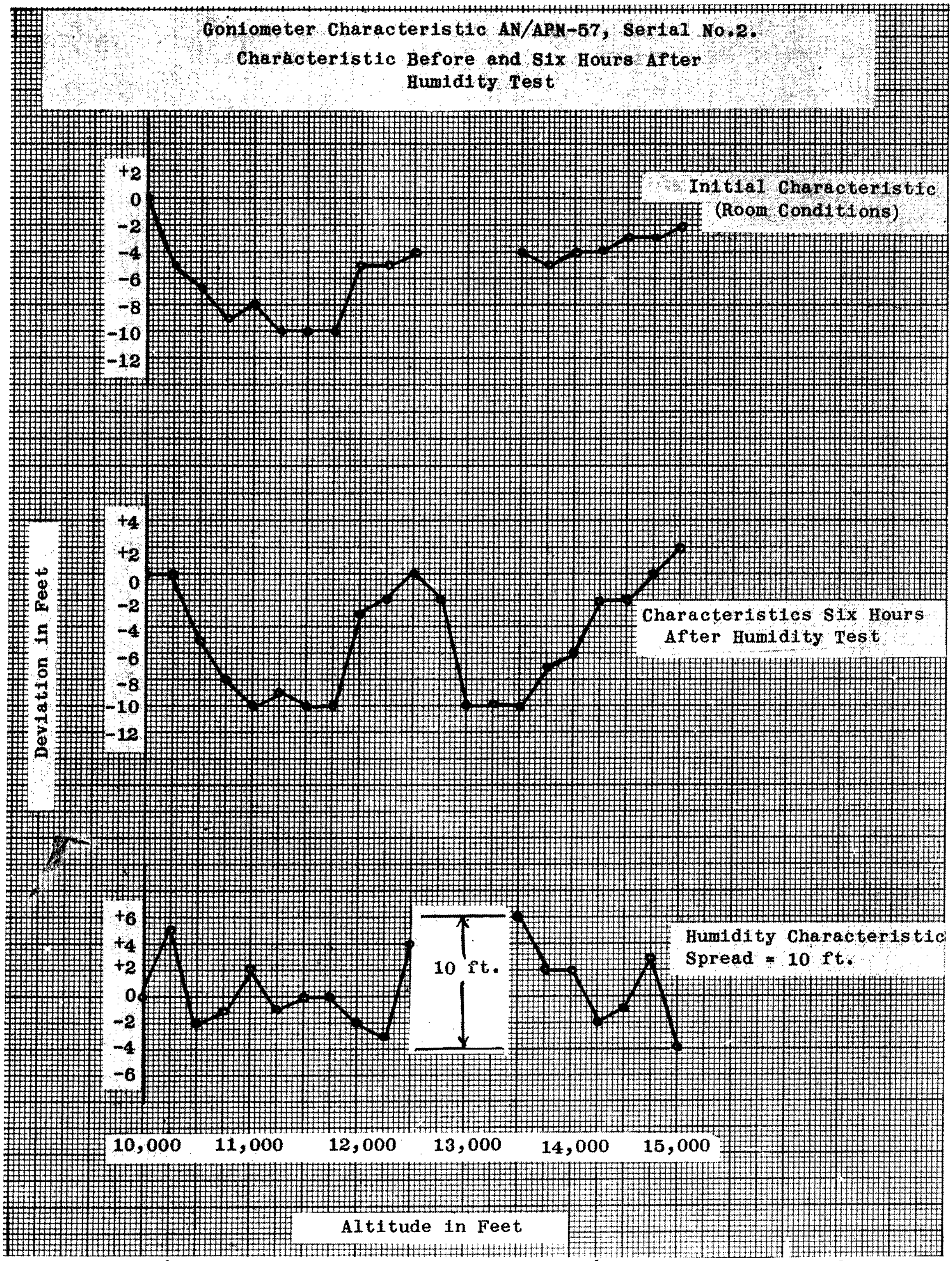


Fig. 26. Goniometer Characteristics, AN/APN-57, Serial No. 2

APPENDIX V
RESULTS OF GROUND TEST OF ALTIMETER AN/APN-57
CONDUCTED AT AREA "C", WRIGHT-PATTERSON AFB

FIRST SERIES

28 July 49
1-5 Aug 49
16-17 Aug 49
19 Aug 49
22-24 Aug 49

Ind No.	RT No.	Surveyed Distance	Dial	Scope	Error
1	11	7750	7760	+10	+20
1	11	7750	7755	+ 5	+10
1	13	7750	7750	0	0
1	11	7875	7880	+10	+15
1	11	7875	7880	+10	+15
1	11	7875	7880	+25	+30
1	11	7875	7880	0	+ 5
1	13	7875	7890	+35	+50
1	13	7875	7880	+10	+15

Smallest error 0 ft.

Largest error +50 ft.

Mean error +18 ft.

Faulty 2C51 tube (V601) in Divider circuit - replaced.

2	14	7875	7790	+ 5	-80
2	13	7875	7785	+10	-80

Indicator did not function properly. Dials rotated to the maximum limit stop and did not return to zero when the calibrate switch was used. Insulation of wire on 3DP1A tube was cut by housing; when the wire grounds on housing, pulse indications are not obtained.

Ind No.	RT No.	Surveyed Distance	Dial	Scope	Error
3	15	5000			
3	16	5000			

No readings were obtained. Dials refused to go to 0 from the negative limit stop. Phase Detector Balance adjusted slightly and 0 was obtained in calibrate position; however, pulse disappeared. Dials remained at 0 in the operate position.

Ind No.	RT No.	Surveyed Distance	Dial	Scope	Error
4	15	5000	5045	0	+45
4	16	5000	5055	0	+55 Dial jittered in Calibrate and Operate positions
4	15	5000	Dial oscillated about +5 feet in Operate position		
4	15	5000	5042	0	+42
4	15	5500	5530	+10	+40
4	15	6500	6535	0	+35
4	15	7875	7912	0	+37 Dial and pulse jittered; Operate position
4	15	8375	8405	+20	+50 Dial and pulse had a 30-foot jitter; Calibrate position
4	15	8875	9005	+10	+40 Dial had a 30-foot jitter; difficult to calibrate correctly
4	15	9375	9398	+10	+33
4	15	10,000	10,025	+25	+50
4	13	10,000	10,030	+ 5	+35 Dial had a 20-foot jitter; Calibrate position

Smallest error	+33ft
Greatest error	+55 ft.
Mean error	+42 ft.

Ind. No.	RT No.	Surveyed Distance	Dial	Scope	Error
5	15	5000	5000	+30	+30
5	15	5000	5025	+10	+35 Dial stopped momentarily then moved 30 ft. cw for a new reading
5	15	5500	5482	+30	+12 Dial jittered about 20 feet; Operate position
5	15	6500	6550	0	+50 Dial jittered
5	15	7875	7900	+10	+35
5	15	8375	8410	0	+35
5	15	8875	8910	-10	+25
5	15	9375	9400	0	+25
5	15	10000	10045	- 5	+40
5	15	10000	10040	- 5	-10 (Pulse and zero marker set at -50)
5	13	10000	10025	+ 5	+30 Scope intensity varied. Disappeared completely then reappeared.

Smallest error +12 ft.

Greatest error +50 ft.

Mean error +32 ft.

Ind. No.	RT No.	Surveyed Distance	Dial	Scope	Error
6	15	5000	5025	+20	+45 Marker pulse disappeared after one reading. Dial did not return to 0 in Calibrate position.
6	16	5000	5045	0	+45
6	15	5000	5040	+ 5	+45 Dial oscillated about 15 feet in Operate position
6	15	5500	5500	+30	+30 Dial and pulse jittered in Calibrate position. Pulse did not return to 0, thereby making frequent adjustments necessary.
6	15	6500	6535	+10	+45 Dial jittered (Calibrate and Operate position)
6	15	7875	7905	+15	+45
6	15	8375	8420	+ 5	+50
6	15	8875	8915	0	+40 Scope intensity varied.
6	15	9375	9410	+ 5	+40
6	15	10000	10045	+ 5	+50 Scope intensity varied.
6	15	10000	10000	+10	+50

Smallest error +30 ft.

Greatest error +50 ft.

Mean error +44 ft.

Ind. No.	RT No.	Surveyed Distance	Dial	Scope	Error
7	No readings - defective upon arrival. Open primary on transformer and broken 2X2A Tube.				
8	15	5000	5025	+10	+35
8	16	5000	5045	+ 0	+45
8	15	5000	5040	+ 0	+40
8	15	5500	5500	+25	+25
8	15	5500	5500	+20	+20
8	15	6500	6538	+ 0	+38 Slight jitter of dial. (Calibrate Position)
8	15	7875	7895	+10	+30
8	15	8375	8405	+ 0	+30 Amplitude of pulse 75% of normal.
8	15	8375	8380	+15	+20
8	15	8875	8903	+10	+38
8	15	9375	9412	- 5	+32
8	15	10000	10030	+ 5	+35
8	15	10000	10035	-55	-20 Pulse and zero marker set at -50 feet.
8	13	10000	10030	+ 0	+30

Smallest error	+20 feet
Greatest error	+45 feet
Mean error	+32 feet

Ind. No.	RT No.	Surveyed Distance	Dial	Scope	Error
9	15	5000	5050	-10	+40
9	15	5000	5050	-60	-10 Zero marker and pulse set at -50.
9	16	5000	5040	+10	+50
9	15	5000	5040	+30	+50 Scope intensity varied.
9	15	5500	5495	+35	+30
9	15	6500	6535	0	+35 Scope intensity varied. Dial and pulse had a 20-foot jitter (Operate and Calibrate positions)
9	15	7875	7900	+15	+40
9	15	8375	8415	+20	+60 Pulse amplitude low; hardly visible above circle.
9	15	8875	8910	0	+35 Pulse leading edge oscillated; difficult to read.
9	15	9375	9408	+10	+43
9	15	10000	10050	0	+50
9	13	10000	10035	+15	+50 Amplitude of pulse 50% of normal

Smallest error	+30 feet
Greatest error	+60 feet
Mean error	+44 feet

Ind. No.	RT No.	Surveyed Distance	Dial	Scope	Error
10	15	5000	5018	- 10	+8
10	15	5000	5025	+ 10	+35
10	16	5000	5040	+ 10	+50 Zero marker moved to -10 in Operate position after being set at 0 in Calibrate position.
10	16	5000	5040	+ 0	+40
10	15	5000	5012	+ 10	+22 Scope intensity varied.
10	15	5000	5050	- 10	+40 Dial oscillated about 100 feet (Calibrate position).
10	15	5500	Amplitude of pulse too short to read. Dials indicate approximately the correct distance of target. Dial had a 100-foot jitter (Calibrate position).		
10	15	6500	6540	+ 0	+40
10	15	7875	7900	+ 10	+35 Zero marker not normal.
10	15	8375	Scope had two circles. Difficult to calibrate.		
10	15	8875	8895	- 10	+25 Scope had two circles. Difficult to calibrate.
10	15	9375	9385	+ 35	+45 Trace fuzzy.
10	15	10000	10020	+ 15	+35 Pulse and dial had a 10-foot jitter (Operate position)
10	13	10000	10000	Impossible to calibrate properly; double circle and pulses noted; zero marker above the lower circle and difficult to see.	

Smallest error	+ 8 feet
Greatest error	+50 feet
Mean error	+34 feet

Ind. No.	RT No.	Surveyed Distance	Dial	Scope	Error
11	15	5000	5025	+10	+35
11	16	5000	5048	+ 0	+48
11	16	5000	5050	-10	+40
11	15	5000	5020	+20	+40 Scope intensity varied.
11	15	5500	5478	+40	+18
11	15	6500	6528	+10	+38 Scope intensity varied.
11	15	7875	7905	+20	+50
11	15	8375	8360	+30	+35
11	15	8875	8910	+ 5	+40
11	15	9375	9395	+25	+45
11	15	10000	10035	+ 5	+40
11	13	10000	10015	+25	+40

Smallest error	+18 feet
Greatest error	+50 feet
Mean error	+39 feet

Ind. No.	RT NO.	Surveyed Distance	Dial	Scope	Error
12	11	7750	Indicator did not function during ARL test of 1 August 1949. Dials went to maximum limit stop and would not return to 0 in Calibrate position.		
		17 August 1949 test after repair by RCA			
12	15	5000	5030	+20	+50
12	15	5500	Did not pick up target. Dial read 5040 feet instead of 0 in Calibrate position. Marker and pulse normal.		
13	13	7875	7920	+30	+75
13	11	7875	7930	+10	+65
13	11	7875	7890	+50	+65
13	11	7875	7920	+25	+70
13	11	7875	7910	+35	+70
13	11	7750	7765	+40	+55
13	11	7500	7525	+25	+50
13	11	7625	7640	+40	+55

Every 3 seconds dial oscillated about 100 feet. Repaired and aligned by RCA; however it failed to work for RCA test. Trouble shooting by RCA incomplete due to lack of time.

Smallest error	+50 feet
Greatest error	+75 feet
Mean error	+63 feet

Ind. No.	RT No.	Surveyed Distance	Dial	Scope	Error
14	15	5000	5010	+25	+35
14	15	5000	5015	+30	+45
14	15	5000	5028	+15	+43

Scope intensity varied. Dial oscillated in Calibrate position. In Operate position on target, dial stopped rotating momentarily, then rotated ccw about 40 feet for a new reading.

Ind. No.	RT No.	Surveyed Distance	Dial	Scope	Error
14	15	5500	5470	+50	+20
14	15	6500	6500	+60	+60

Scope intensity varied and was not visible at times. Pulse amplitude low, scope indications fuzzy; focus adjustment did not clear fuzziness.

Ind. No.	RT No.	Surveyed Distance	Dial	Scope	Error
14	15	7875	7900	+10	+35 Scope indications fuzzy.
14	15	8375	8350	+50	+25 Scope intensity varied. Pulse amplitude low.
14	15	8875	8880	+30	+35 Pulse amplitude 50% of normal and varied in contour.
14	15	9375	9390	+30	+45
14	15	10000	10020	+15	+35 Pulse amplitude 50% of normal. Dial and pulse had a 10-foot jitter (Operate position).
14	13	10000	10020	+25	+45 Pulse amplitude low, dial and pulse jitter, scope indications fuzzy.
14	13	10000	10030	+15	+45
14	13	10000	Could not calibrate, scope indications fuzzy.		

Smallest error	+20 feet
Greatest error	+60 feet
Mean error	+39 feet

Ind. No.	RT No.	Surveyed Distance	Dial	Scope	Error
15	13	5000	5020	+30	+50
15	13	5125	5160	+15	+50
15	13	5250	5290	+10	+50
15	13	5375	5410	+20	+55
15	13	5500	5540	+10	+50
15	13	5625	5640	+30	+45
15	13	5750	5775	+25	+50
15	13	6500	6540	+10	+50
15	11	7750	7790	+20	+60
15	13	7875	7910	+20	+55
15	11	7875	7900	+30	+55
15	14	7875	7920	+10	+55
15	13	7875	7910	+20	+55
15	11	7875	7910	+10	+45
15	13	7875	7905	+25	+55

The indicator was tested on 26 August in the Laboratory after completion of tests at the surveyed range and it is observed that the dial and pulse had a 20-foot jitter in the Calibrate position. A one-hour warm-up did not eliminate the jitter.

Smallest error	+45 feet
Greatest error	+60 feet
Mean error	+52 feet

16	11	Failed on first reading.
		RCA did some trouble shooting; however, due to lack of time repairs were not completed.

Ground Tests of Altimeter AN/APN-57, Summary of Results
Part II (Readings by RCA)

10-12 Aug 49

Ind. No.	RT No.	Surveyed Distance	Dial	Scope	Error
6	13	5250	5290	0	+40
		5500	5540	+10	+50
		6000	6035	+10	+45
		6500	6530	+30	+60
		7500 Intermittent. No reading. Scope intensity varied.			
6	13	8375	8410	+15	+50
		8875	8903	+20	+48
		9375 No marker reading.			

Smallest error	+40 feet
Greatest error	+60 feet
Mean error	+48 feet

Ind. No.	RT No.	Surveyed Distance	Dial	Scope	Error
9	13	5250	5290	0	+48
9	13	5500	5535	+10	+45
9	13	6000	6016	+25	+41
9	13	6500	6533	+10	+43
9	13	7500	7528	+15	+43
9	13	7875	7898	+10	+33
9	13	8375	Circle failure, no readings - scope intensity varied.		
9	13	8875	8903	+20	+48
9	13	9375	9405	+20	+50
9	13	9875	9908	+20	+53
9	14	9875	9890	+45	+60
9	12	9875	9873	+55	+53
9	16	9875	9918	0	+43

Smallest error	+33 feet
Greatest error	+60 feet
Mean error	+46 feet

Ind. No.	RT No.	Surveyed Distance	Dial	Scope	Error
10	13	5250	5270	+25	+45
10	13	5500	5525	+30	+55
10	13	6000	6008	+45	+53
10	13	6500	6527	+25	+52
10	13	7500	7513	+40	+53
10	13	7875	7885	+50	+60
10	13	8375	8390	+40	+55
10	13	8875	8880	+55	+60
10	13	9375	9370	+55	+50
10	13	9875	9887	+40	+53
10	14	9875	9900	+40	+65
10	14	9875	9893	+40	+58
10	14	9875	9895	+35	+55
10	12	9875	9870	+40	+35
10	12	9875	9875	+40	+40
10	16	9875	9885	+45	+55

Smallest error	+35 feet
Greatest error	+65 feet
Mean error	+53 feet

Ind. No.	RT No.	Surveyed Distance	Dial	Scope	Error
12	13	8375	8410	+15	+50
12	13	8875	8900	+20	+45
12	13	9375	9395	+20	+45
12	13	9875	9900	+25	+50
12	14	9875	9910	+20	+55
12	12	9875	9904	+25	+54
12	16	9875	9905	+25	+55

Smallest error	+45 feet
Greatest error	+55 feet
Mean error	+51 feet

Ind. No.	RT No.	Surveyed Distance	Dial	Scope	Error
15	13	5000	5035	+5	+40
15	13	5250	5285	+5	+40
15	13	5500	5553	+10	+43
15	13	5750	5775	+12	+37
15	13	6000	6025	+20	+45
15	13	6250	6285	+15	+50
15	13	6500	6540	+5	+45
15	13	7500	7540	+8	+48
15	13	7750	7780	+20	+50
15	13	7875	7905	+18	+48
15	13	8128	8160	+18	+50
15	13	8375	8415	+8	+48
15	13	8625	8670	+5	+50
15	13	8875	8915	+8	+48
15	13	9125	9160	+8	+43
15	13	9375	9405	+15	+45
15	13	9625	9660	+15	+50
15	13	9877	9910	+10	+43
15	13	10002	10035	+5	+38

Smallest error +37 feet

Greatest error +50 feet

Mean error +45 feet

APPENDIX VI

Results of Ground Test of Altimeter AN/APN-57 **7 Oct 1949**

Conducted at Area C, Wright-Patterson AFB
Second Series
VIDEO PULSE SET TO -40 FT. IN
CALIBRATE POSITION FOR ALL TESTS

ONE INDICATOR AND ONE R-T UNIT AT VARIOUS DISTANCES

INDICATOR	R-T	SURVEYED DISTANCE	DIAL	SCOPE	INDICATED DISTANCE	ERROR
8	15	5000	5043	-43	5000	0
"	"	5500	5530	-40	5490	-10
"	"	6000	6035	-25	6010	+10
"	"	7875	7890	-35	7855	-20
"	"	8125	8145	-35	8110	-15
"	"	8375	8390	-30	8360	-15
"	"	8875	8900	-40	8860	-15
"	"	9375	9410	-40	9370	- 5
"	"	10,000	10,030	-40	9990	-10
11	15	5,000	5,010	- 5	5,005	+ 5
"	"	5,500	5,500	+ 5	5,505	+ 5
"	"	6,000	5,995	+10	6,005	+ 5
"	"	7,875	7,875	0	7,875	0
"	"	8,125	8,125	0	8,125	0
"	"	8,375	8,385	0	8,385	+10
"	"	8,875	8,880	0	8,880	+ 5
"	"	9,375	9,360	+25	9,385	+10
"	"	10,000	10,015	-10	10,005	+ 5

ONE INDICATOR AND ONE R-T UNIT AT VARIOUS DISTANCES

INDICATOR	R-T	SURVEYED DISTANCE	DIAL	SCOPE	INDICATED DISTANCE	ERROR
15	15	5,000	5,028	-35	4,993	-7
"	"	5,500	5,525	-30	5,495	-5
"	"	6,000	6,030	-35	5,995	-5
"	"	7,875	7,905	-35	7,870	-5
"	"	8,125	8,160	-40	8,120	-5
"	"	8,375	8,410	-40	8,370	-5
"	"	8,875	8,909	-40	8,869	-6
"	"	9,375	9,408	-30	9,478	+3
"	"	10,000	10,035	-40	9,995	-5

ONE R-T UNIT WITH VARIOUS INDICATORS, AT TWO DISTANCES

INDICATOR	R-T	SURVEYED DISTANCE	DIAL	SCOPE	INDICATED DISTANCE	ERROR
8	11	8,375	8,390	-20	8,370	-5
8	"	10,000	10,030	-30	10,000	0
11	"	8,375	8,350	+40	8,390	+15
11	"	10,000	9,995	+20	10,015	+15
15	"	8,375	8,395	-25	8,370	-5
15	"	10,000	10,020	-25	9,995	-5
8	13	8,375	8,385	-30	8,365	-10
8	"	10,000	10,025	-25	10,000	0
11	"	8,375	8,368	+12	8,380	+5
11	"	10,000	9,990	+10	10,000	0
15	"	8,375	8,400	-30	8,370	-5
15	"	10,000	10,029	-32	9,997	-3
8	15	8,375	8,390	-30	8,360	-15
8	"	10,000	10,030	-40	9.990	-10
11	"	8,375	8,385	0	8,385	+10
11	"	10,000	10,015	-10	10,005	+5
15	"	8,375	8,410	-40	8,370	-5
15	"	10,000	10,035	-40	9,995	-5

ONE INDICATOR WITH VARIOUS R-T UNITS, AT TWO DISTANCES

INDICATOR	R-T	SURVEYED DISTANCE	DIAL	SCOPE	INDICATED DISTANCE	ERROR
8	11	8,375	8,390	-20	8,370	-5
"	11	10,000	10,030	-30	10,000	0
"	13	8,375	8,385	-20	8,365	-10
"	13	10,000	10,025	-25	10,000	0
"	15	8,375	8,390	-30	8,360	-15
"	15	10,000	10,030	-40	9,990	-10
11	11	8,375	8,350	+40	8,390	+15
"	11	10,000	10,000	0	10,000	0
"	13	8,375	8,368	+12	8,380	+5
"	13	10,000	9,990	+10	10,000	0
"	15	8,375	8,385	0	8,385	+10
"	15	10,000	10,015	-10	10,005	+5
15	11	8,375	8,395	-25	8,370	-5
"	11	10,000	10,020	-25	9,995	-5
"	13	8,375	8,400	-30	8,370	-5
"	13	10,000	10,029	-32	9,997	-3
"	15	8,375	8,410	-40	8,370	-5
"	15	10,000	10,035	-40	9,995	-5

APPENDIX VII
ACCURACY TEST OF ALTIMETER AN/APN-57
AT EDWARDS AIR FORCE BASE

TEST PROGRAM AND DATA

ORDNANCE DEPARTMENT
ABERDEEN BOMBING MISSION
EDWARDS AIR FORCE BASE
MUROC, CALIFORNIA

Pegee/fk
Ext. 168
9 January 1950

W O R K   S H E E T

SUBJECT: Accuracy Test of Radar Altimeters AN/APN-42(XA-2), AN/APN-57, SCR-718-C.

TO: All personnel concerned.

1. General

a. The following described test is authorized by teletype ORDBG-DPA 5127, 31 August 1949. Additional reference file ABM 413.44/4, 25 July 1949; file ABM 413.44/5, 24 August 1949; ABM 413.44/7, 10 October 1949.

b. The purpose of the program is to provide data for comparison of the aircraft altitude at a given point as determined by the Precision Range instrumentation against the altitude registered by the subject Radar Altimeters of a B-29 Test aircraft at the same point and at the same time.

c. The following described program of flights was established by agreement at a conference 6 March 1950, Lt. Col. John D. Armitage, Commanding Officer of ABM, Mr. Pegee and Mr. Scharf representing ABM, and Mr. Segen, Mr. Limoli, and Mr. Georgi representing AMC relative to the subject test.

d. AMC Project - E. O. 108-90.

2. Field Data Required

a. Instrumentation required for each run is specified by Paragraph 5, "Test Flights".

b. Normal SOP for ballistic data bombing except:

(1) Camera plates will be identified by station designation, date and by Pass Number as indicated Para. 5, "Test Flight". Each pass is equivalent to a normal bomb run.

(2) Askanias not required except on pass 19.

(3) Mitchell, Bowen-Knapp station will not be operated.

(4) Oscillograph will record all runs. Instrumentation such as S.M., Geophones, etc., not required will not be operated or not recorded during runs.

(5) Impact area need not be manned nor is weather data required for this program.

(6) All field notes will show the applicable pass number rather than the normal ABM round numbers.

c. The set of plates of BF Cameras will be coded the same as for B-45 missions; the AB plates as for the B-29 missions. The Program Director should be guided by the desirability for a maximum number of images on each set of plates and will code at his discretion.

d. For guidance, the Chief of the Range Operations Section will be provided an outline of the functioning characteristics of the ABM electronic set-up in the aircraft, its operation and tie-in with other instrumentation in the aircraft.

e. Except for Passes 1 and 2, Survey Data required will be made the subject of a separate directive based on the results of the first two passes over the range.

f. Survey Data for the first two passes will require:

(1) Selection of 5 to 10 points by the ABM Computing Unit given in a-b coordinates.

(2) Establishment and identification by properly marked and reasonably secure stakes of these points on the ground by triangulation from known bench marks.

(3) Determination of the elevation of the selected points. Means of determination of elevation will be at the discretion of the Chief of Range Operations with accuracy of determination of ±5 feet the controlling factor.

g. The Chief of the Range Operations Section will prepare a comprehensive report of the details and observations of the program and will consolidate and check all data submitted to Chief of Operations Branch.

3. Electronics Equipment Installation

a. Electronics instrumentation required in the aircraft will be installed by the ABM Electronics Section.

b. The Chief of the ABM Engineering Section has the responsibility for adaptation of the ABM electronics equipment to the requirements of the radar installation and has the responsibility of coordinating with AMC project personnel all details to effect such installation.

c. The Chief of the Engineering Section will prepare for publication a detailed SOP for operation of the ABM equipment. A description of its purpose and function, of how and when the data will be recorded by the ground instrumentation, the relationship to and correlation with the radar data plus any directions or requirements that will expedite the procurement of or improve the accuracy of the data.

d. The Chief of the Engineering Section will make certain the Chief of Range Operations is thoroughly familiar with the adapted instrumentation and how it will be used prior to the first flight.

e. Upon completion of the Program, the Chief of the Engineering Section will prepare a formal report outlining the procedure, the execution, and results obtained. No conclusions should be drawn relative to the suitability of the radar equipment, except the results obtained may be compared to the results from the range instrumentation.

4. ABM Computing Unit

a. The Computing Unit will be responsible for reduction of all data required.

b. After data has been submitted for pass one and two:

(1) The Computing Unit will determine the a, b coordinates for ten points at random and will give an azimuth bearing from "A and B" bench marks, or at the discretion of the Computing Unit the azimuth reference may be given from other bench marks if more desirable for survey of points.

(2) After survey for elevation, the data will be returned to the Computing Unit for incorporation in tabulation of data.

(3) If possible, the data from the aircraft altimeter (35 mm film) will be forwarded for inclusion with the tabulation.

c. Details of operation of equipment and conduct of program will be forwarded per paragraph 3e.

d. Extent of data required from remaining passes will be established, based on results of passes one and two.

5. <u>Test Flights</u>

a. For convenience, the program has been broken down into three flights with an appropriate number of passes per flight. The conditions of each pass is lat r described.

b. A/C personnel have been made aware of the limitations of the ABM ballistic camera.field of view and all following described passes are based on bi-secting as nearly as possible the camera base lines and all flights will be made in the direction of the normal line of flight.

c. Flight One will be flown at 26,700 feet calibrated indicated altitude above sea level (approx. 24,000 feet above terrain). For all passes flown in this flight, Ballistic Cameras EF and AB will be exposed successively as the plane passes into the respective fields of view.

Pass 1	Aircraft straight and level.
Pass 2	Aircraft straight and level.
Pass 3	Left wing down 5°. Line of flight straight and level.
Pass 4	Left wing down 10°. Line of flight straight and level.
Pass 5	Right wing down 5°. Line of flight straight and level.
Pass 6	Right wing down 10°. Line of flight straight and level.

d. Flight Two same altitude (26,700 feet) and same ballistic camera requirements as Flight One.

Pass 7	Nose high 3°. Line of flight straight and level.
Pass 8	Nose high 6°. Line of flight straight and level.
Pass 9	Tail high 3°. Line of flight straight and level.
Pass 10	Tail high 6°. Line of flight straight and level.
Pass 11	Aircraft straight and level. Move radar antenna 3° aft.
Pass 12	Airacraft straight and level. Move radar antenna 6° aft.
Pass 13	Aircraft straight and level. Move radar antenna 3° forward.
Pass 14	Aircraft straight and level. Move radar antenna 6° forward.

e. Flight Three will be flown at 18,700 feet calibrated indicated altitude (approximately 16,000 feet above terrain). Only E and F cameras will be operated. Note requirement for Askanias, Pass 19.

Pass 15 Aircraft straight and level.

Pass 16 Aircraft straight and level.

Pass 17 Left wing down 30°. Line of flight straight and level (doubtful).

Pass 18 Right wing down 30°. Line of flight straight and level (doubtful).

Pass 19 Aircraft straight and level. Pass will be made from south to north over the center of the dry lake bed. Ballistic Camera will not be used. Askanias will track aircraft into beginning of run and will start exposures just before aircraft reaches south edge of lake bed and will continue photographing for three minutes.

/s/ Walter O. Pegee
WALTER O. PEGEE
Chief, Operations Branch

APPROVED:

JOHN D. ARMITAGE
Lt Col, Ord Dept
Commanding

ACCURACY TEST DATA
FOR
ALTIMETER AN/APN-57

Aberdeen Bombing Mission | Edwards Air Force Base

Date	Pass	Counter	Attitude of Aircraft Bank	Climb	Correct Alt. above Terrain	AN/APN-57 Alt. Reading	Final Difference
16 Mar 50	1	58	LWD 1°	NU 2°	25,019	25,075	56 feet
		59			25,028	25,093	65
		60			25,037	25,102	65
		65			25,088	25,153	65
		70			25,152	25,225	73
20 Mar 50	1 B	48	RWD 2°	NU 1°	24,336	24,370	34 feet
		52			24,352	24,390	38
		54			24,371	24,410	39
		57			24,384	24,420	36
		58			24,390	24,425	35
		62			24,410	24,448	38
		63			24,416	24,465	39
		67			24,441	24,478	37
		77			24,527	24,571	44
		79			24,543	24,600	57
23 Mar 50	2A	9	RWD 1°	NU 1°	23,506	23,565	59 feet
		10			23,528	23,588	60
		11			23,546	23,609	63
		12			23,564	23,624	60

Date	Pass	Counter	Attitude of Aircraft: Bank	Attitude of Aircraft: Climb	Correct Alt. above Terrain	AN/APN-57 Alt. Reading	Final Difference
23 Mar 50		13			23,576	23,645	69 feet
		14			23,585	23,650	65
2 Apr 50	3A	18	LWD 9°	NU 2°	24,558	24,990	432
		22	6°	4°	24,515	24,820	305
		25	6°	5°	24,522	24,840	318
		26	6°	5°	24,531	24,895	364
		27	6°	5°	24,544	24,960	416
		33	9°	7°	24,655	25,280	625
		38	7°	5°	24,716	25,180	464
		44	6°	3°	24,721	[illegible],080	359
		45	6°	3°	24,716	[illegible]5,075	359
		51	6°	3°	24,711	25,265	554
3 Apr 50	4	89	LWD 10°		24,590	25,230	640
		93			24,662	25,470	808
		94			24,672		
		95			24,682	25,573	891
		99			24,714	25,685	971
		103			24,731	25,925	1194
		108			24,745	25,950	1205
		111			24,751	25,960	1209
		116			24,718	25,850	1132
		119			24,712	25,890	1178

Date	Pass	Counter	Attitude of Aircraft Bank	Attitude of Aircraft Climb	Correct Alt. above Terrain	AN/APN-57 Alt. Reading	Final Difference
3 Apr 50	5	160	RWD 5°		24,756	24,938	182
		165			24,831	24,992	161
		170			24,861	25,060	199
		173			24,867	25,105	238
		174			24,870	25,105	235
		175			24,871	25,130	259
		183			24,885	25,075	190
		187			24,919	25,122	203
		191			24,956	25,210	254
		193			24,973	25,220	247
3 Apr 50	6	205	RWD 10°		24,700	25,032	332
		208			24,782	25,190	408
		212			24,818	25,195	377
		213			24,825	25,200	375
		214			24,831	25,218	387
		217			24,835	25,275	430
		220			24,860	25,338	478
		225			24,884	25,350	466
		228			24,931	25,410	479
		232			24,989	25,530	541

Date	Pass	Counter	Attitude of Aircraft Bank	Attitude of Aircraft Climb	Correct Alt. above Terrain	AN/APN-57 Alt. Reading	Final Difference
3 Apr 50	7	249		NU 3°	24,509	24,585	76
		252			24,559	24,632	73
		256			24,635	24,690	55
		257			24,650	24,712	62
		258			24,660	24,715	55
		261			24,690	24,757	67
		267			24,740	24,802	62
		272			24,782	24,872	90
		279			24,864	24,942	78
		282			24,881	24,960	79
3 Apr 50	8	298		NU 6°	24,285	24,475	190
		303			24,332	24,515	183
		311			24,368	24,480	112
		317			24,370	24,510	140
		323			24,392	24,550	158
		324			24,397	24,560	163
		325			24,399	24,550	151
		329			24,412	24,575	163
		335			24,422	24,590	168
		342			24,454	24,665	211

Date	Pass	Counter	Attitude of Aircraft		Correct Alt. Above Terrain	AN/APN-57 Alt. Reading	Final Difference
			Bank	Climb			
3 Apr 52	9	360		TU 3°	23,883	23,942	59
		363			23,879	23,930	51
		364			23,874	23,928	54
		365			23,872	23,930	58
		369			23,862	23,940	78
		372			23,860	23,968	108
		373			23,857	23,938	81
		375			23,864	23,930	66
		377			23,885	23,953	68
		381			23,937	23,995	58
3 Apr 50	12	475	0	0	23,253	23,532	279
		476			23,256	23,538	282
		480			23,265	23,550	285
		482			23,272	23,570	298
		483			23,275		
		484			23,279		
		490			23,323		
		493			23,346	23,660	314
		499			23,386	23,738	352
		503			23,411	23,750	339

Antenna feed 6° aft

Date	Pass	Counter	Attitude of Aircraft		Correct Alt. above Terrain	AN/APN-57 Alt. Reading	Final Difference
			Bank	Climb			
3 Apr 52	13	513	0	0	23,218	23,260	42
		517			23,233	23,280	47
		520			23,265	23,315	50
		525			23,294	23,347	53
		529			23,315	23,358	43
		532			23,332	23,385	53
		533			23,338	23,388	50
		534			23,344	23,295	51
		539			23,381	23,430	49
		542			23,394	23,460	66
		545			23,405	23,480	75

Antenna feed 3° forward

3 Apr 50	14	559	0	0	23,162	23,250	88
		562			23,181	23,285	104
		565			23,196	23,302	106
		568			23,217	23,313	96
		574			23,251	23,335	84
		575			23,263	23,360	97
		576			23,273	23,359	86
		581			23,316	23,400	84
		585			23,372	23,475	103
		589			23,391	23,490	99

Antenna feet 6° forward

Date	Pass	Counter	Attitude of Aircraft Bank	Attitude of Aircraft Climb	Correct Alt. above Terrain	AN/APN-57 Alt. Reading	Final Difference
28 Mar 50	15	10	0	0	15,356	15,412	56
		11			15,415	15,472	57
		12			15,473	15,535	62
		13			15,518	15,580	52
28 Mar 50	16	90	0	0	15,392	15,435	43
		91			15,423	15,460	37
		95			15,453	15,480	27
		96			15,459	14,495	36
		97			15,465	15,500	35
		101			15,491	15, 523	32
		104			15,511	15,550	39
		105			15,520	15,558	38
		109			15,581	15,628	47
		110			15,589	15,642	53
29 Mar 50	17A	8	RWD 1°	0	15,328	15,360	32
		10			15,363	15,395	32
		12			15,375	15,395	30
		15			15,404	15,460	56
		16			15,415	15,450	35
		17			15,425	15,470	45
		19		NU 1°	15,447	15,510	63

Date	Pass	Counter	Attitude of Aircraft Bank	Attitude of Aircraft Climb	Correct Alt. above Terrain	AN/APN-57 Alt. Reading	Final Difference
29 Mar 50		21			15,486	15,530	44
		23			15,506	15,555	49
		24			15,517		
29 Mar 50	18	120	0	0	15,911	15,974	63
		121			15,925	15,979	54
		122			15,939	15,992	53
		128			16,014	16,065	50
		130			16,038	16,075	37
		131			16,047	16,089	52
		133			16,061	16,110	49
		136			16,080		
		137			16,095		
		140			16,108	16,170	62
29 Mar 50	19	182	RWD 1°	NU 1°	16,603	16,622	19
		183	LWD 1°		16,608	16,625	17
		187	LWD 15°		16,629		
		193	LWD 33°		16,656	19,972	3316
		194	LWD 33°		16,658	19,008	2350
		195	LWD 33°		16,658	19,790	3132
		196	LWD 33°		16,657	19,880	3223

Date	Pass	Counter	Attitude of aircraft Bank	Attitude of aircraft Climb	Correct Alt. above Terrain	AN/APK-57 Alt. Reading	Final Difference
29 Mar 50		205	RWD 26°		16,656	18,670	2014
		210	RWD 32°		16,657	19,775	3118
		211	RWD 32°		16,650	19,658	3008
		212	RWD 30°		16,640	19,305	2665
		221	RWD 31°		16,523	19,302	2779
		224	RWD 30°		16,540	19,130	2590
		232	RWD 2°		16,683	16,715	32
		233	RWD 2°		16,698	16,735	37
		234	RWD 2°		16,711	16,750	39
		236	RWD 2°		16,737	16,753	16
29 Mar 50	20	272	RWD 1°	0	16,602	16,630	28
		277	LWD 2°		16,612	16,640	28
		280	LWD 13°		16,619	17,092	473
		284	LWD 19°		16,624	17,800	1176
		292	LWD 27°		16,613	19,080	2467
		314	RWD 19°		16,606	17,500	894
		323	RWD 26°		16,605	18,390	1785
		328	RWD 28°		16,631	18,720	2089
		334	RWD 25°		16,621		
		350	RWD 32°		16,599	19,205	2606

Date	Pass	Counter	Attitude of Aircraft Bank	Climb	Correct Alt. above Terrain	AN/APN-57 Alt. Reading	Final Difference
29 Mar 50		351	RWD 32°		16,594	19,220	2626
		361	RWD 17°		16,628	17,260	632
		369	RWD 1°		16,644	16,652	8
		371	RWD 1°		16,651	16,655	4
		374	0		16,656	16,658	2
		379	0		16,624	16,640	16

APPENDIX VIII

Pattern Measurements of Antenna Assembly AS-368/APN-57

1. Pattern measurements of Antenna Assembly AS-368/APN-57 were conducted at Ipswich Test Station, a part of the Air Force Cambridge Research Laboratories, Boston, Massachusetts, on 15 and 16 September 1949 by Capt Georgi and the following personnel of the Ipswich Test Station: Messrs. John Baker, Ralph Hiatt, and Mrs. Tine. These tests were conducted to obtain the radiation patterns of the antenna with the feed centered and with the feed tilted off center. The feed is tiltable so that corrections may be made for changes of attitude of the aircraft. From these patterns the beam width at half-power points and the attenuation of the minor lobes were determined.

2. The following is a diagram of the test setup:

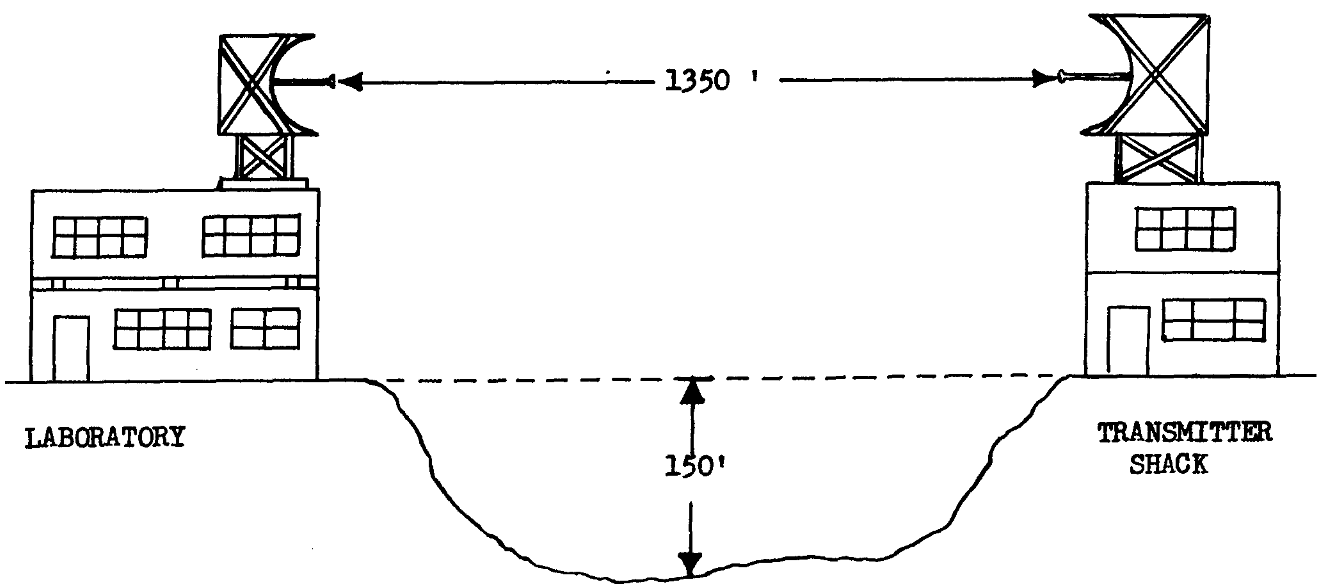


Fig. 27
ANTENNA TEST SETUP

The laboratory and transmitter shack are on top of hills approximately one quarter of a mile apart with a depression approximately 150 feet deep between them. This depression helps to eliminate ground reflections. The antenna to be tested (AS-368/APN-57) was mounted in a mount on top of the laboratory, the mount being motor driven in both azimuth and elevation. Radiation was detected by a bolometer connected to the antenna feed, and the bolometer output was fed into an amplifier and recorder. The antenna on top of the transmitter shack was 10 feet in diameter, with a beamwidth of less than a degree at X-band. The crystal-controlled transmitter was set for 3.238 cm; the center frequency of Altimeter AN/APN-57 is 9375 mc.

3. The patterns were made in the following manner: After the feed of the antenna was accurately centered in the dish, the recorder graph paper was adjusted for azimuth centering; next the antenna was adjusted in elevation to obtain maximum output so that the recorder amplifier gain could be properly set and locked. The antenna mount was then rotated 90 degrees off center and the pattern taking begun. From this point on, the only change in the test setup was that of altering the angular position of the feed of Antenna Assembly AS-368/APN-57.

4. A summary of the results as interpreted from the graphs follows:

Graph #1. For this measurement the feed was centered in the dish with a machinist level graduated in .0001 inches. [See Figure 28.]

Results: The beamwidth of the main lobe was $1.7^\circ \pm .1^\circ$ at the half-power points. The sidelobes were down 23 db or more, and the overall pattern was good.

Graph #2 (90° graph paper used) The feed was adjusted in what appeared to be the center of the dish by means of Trim Control Box C-226/APS-10. The Trim Control Box was attached to the frame of the antenna mount and adjusted so the ball was centered before it was connected to the feed of the antenna. The antenna dish was also zeroed in azimuth and elevation; therefore a zero reference level was established between the two and any change from this could be noted on the trim control box. It was however determined by measurement that the feed was off center by approximately 30 minutes. [See Figure 29.]

Results: The beamwidth of the main lobe increased to 3° and one side lobe was only 5 db down.

Graph #3. This is similar to Graph #2 except the pattern has been expanded 5 to 1 (plotted on 18° graph paper). The feed was centered by means of the trim control box. [See Figure 30.]

Results: The beamwidth of the main lobe was 3.2°. The strongest side lobe was down 16 db. The differences between patterns 2 and 3 are probably due to the inability of the engineer to exactly duplicate the feed centering with the trim control box.

Graph #4. Made with the feed first centered and then shifted off 1° and 2°. [See Figure 31]

Results: (1) The first pattern (feed centered) has a 2° beamwidth and the side lobes are 26 db down. (2) The second pattern (feed tilted 1° off center) has a 2.2° beamwidth and the side lobes are 21 db down. (3) The third pattern (feed tilted 2° off center) has a 2.2° beamwidth and the side lobes are 17 db down.

Graph #5, 6 and 7. For these measurements the feed was first accurately centered and then moved to the left of center 3° and 6°. 6° is the maximum available displacement of the feed from center. [See Figure 32]

Results: (1) With the feed centered (Graph #5) the beamwidth was 2° and the first side lobe was down 18 db. (2) With the feed tilted off center 3° (Graph #6) the beamwidth increased to 2.4° and the side lobes were only 8 db down, with the overall pattern of the antenna poor. (3) With the feed tilted off center 6° (Graph #7) the beamwidth was 2.1° and the side lobes moved up to within 6 db of the main lobe.

Graphs #8, 9 and 10. The feed was first accurately centered and then moved to the right of center 3° and 6°. [See Figure 33]

Results: (1) With the feed centered (Graph #8) the beamwidth was 2.2° and the side lobes were down 22 db. (2) With the feed off center 3° (Graph #9) the beamwidth was 2.4°, the side lobes were down 6 db, and the overall pattern of the antenna poor. (3) With the feed off center 6° (Graph #10) the beamwidth was 3°, the side lobes were 4 db down, and the overall pattern poor.

Conclusions:

(1) Due to the deterioration of the antenna pattern when the feed is in any position except center, the feed should be centered and locked in that position.

(2) A mathematical study of the effect of antenna beamwidth on altitude readings over various types of terrain seems desirable.

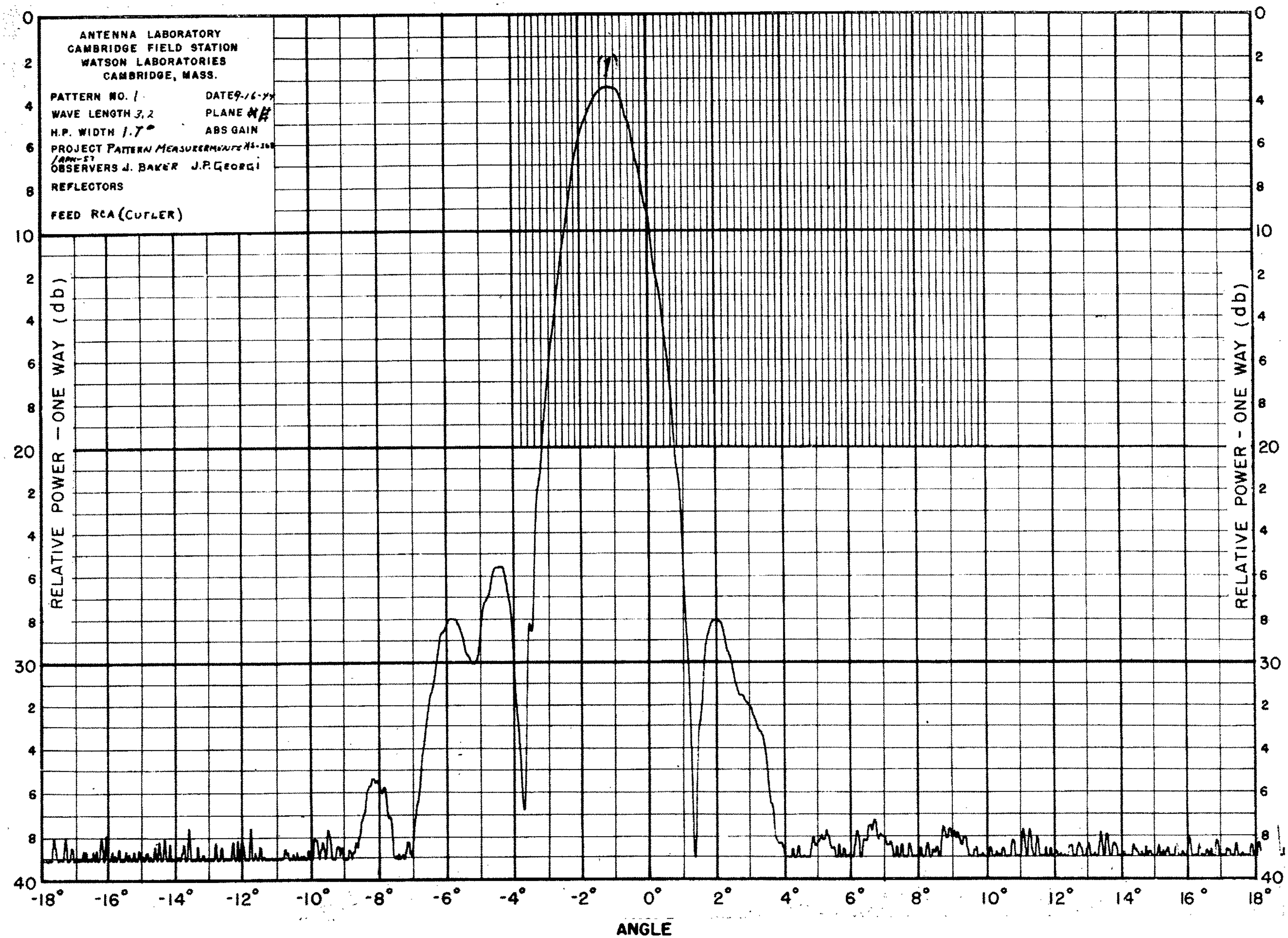


Fig. 28. Antenna Patterns, Antenna Assembly AS-368/APN-57

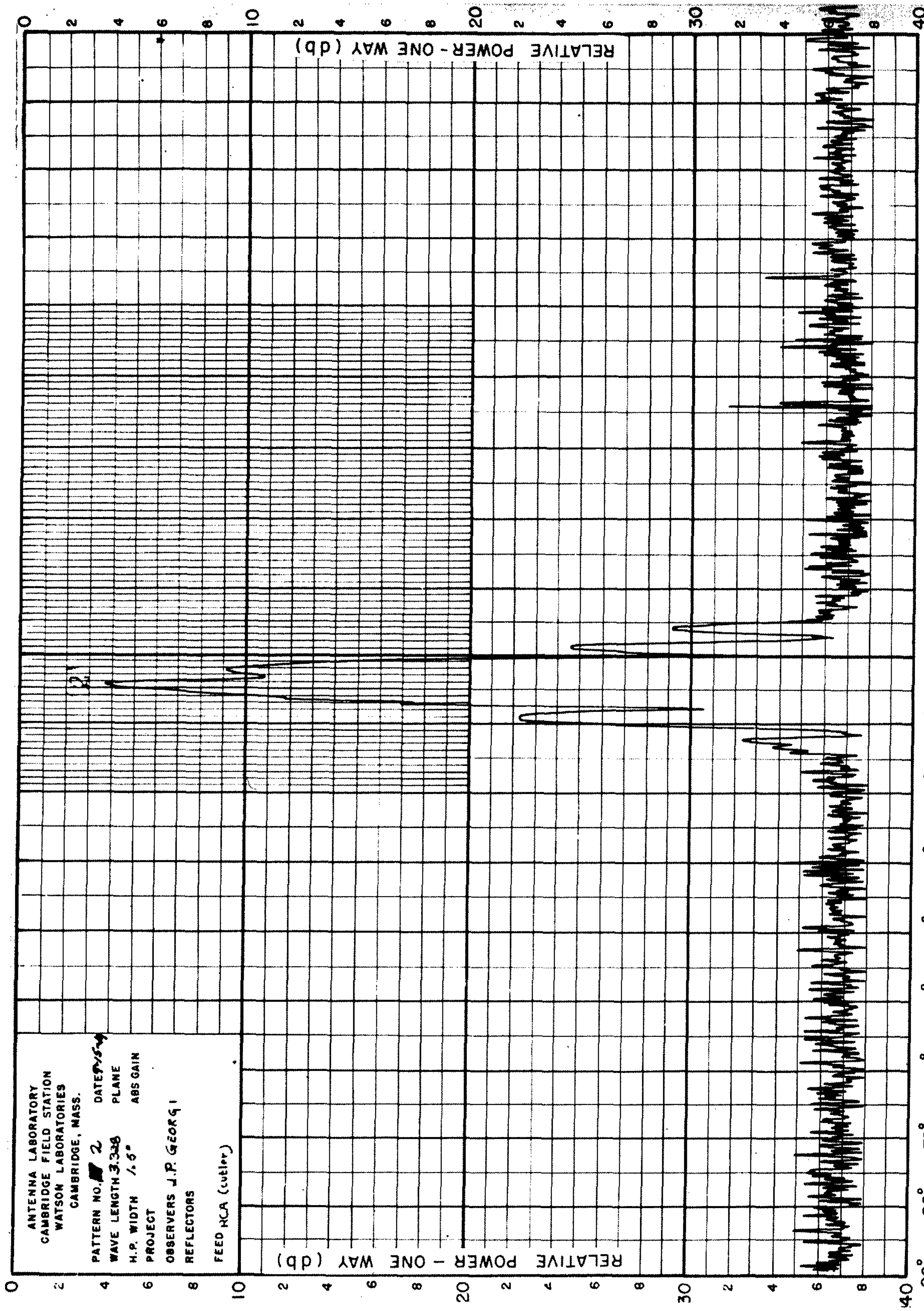


Fig. 29. Antenna Patterns, Antenna Assembly AS-368/APN-57

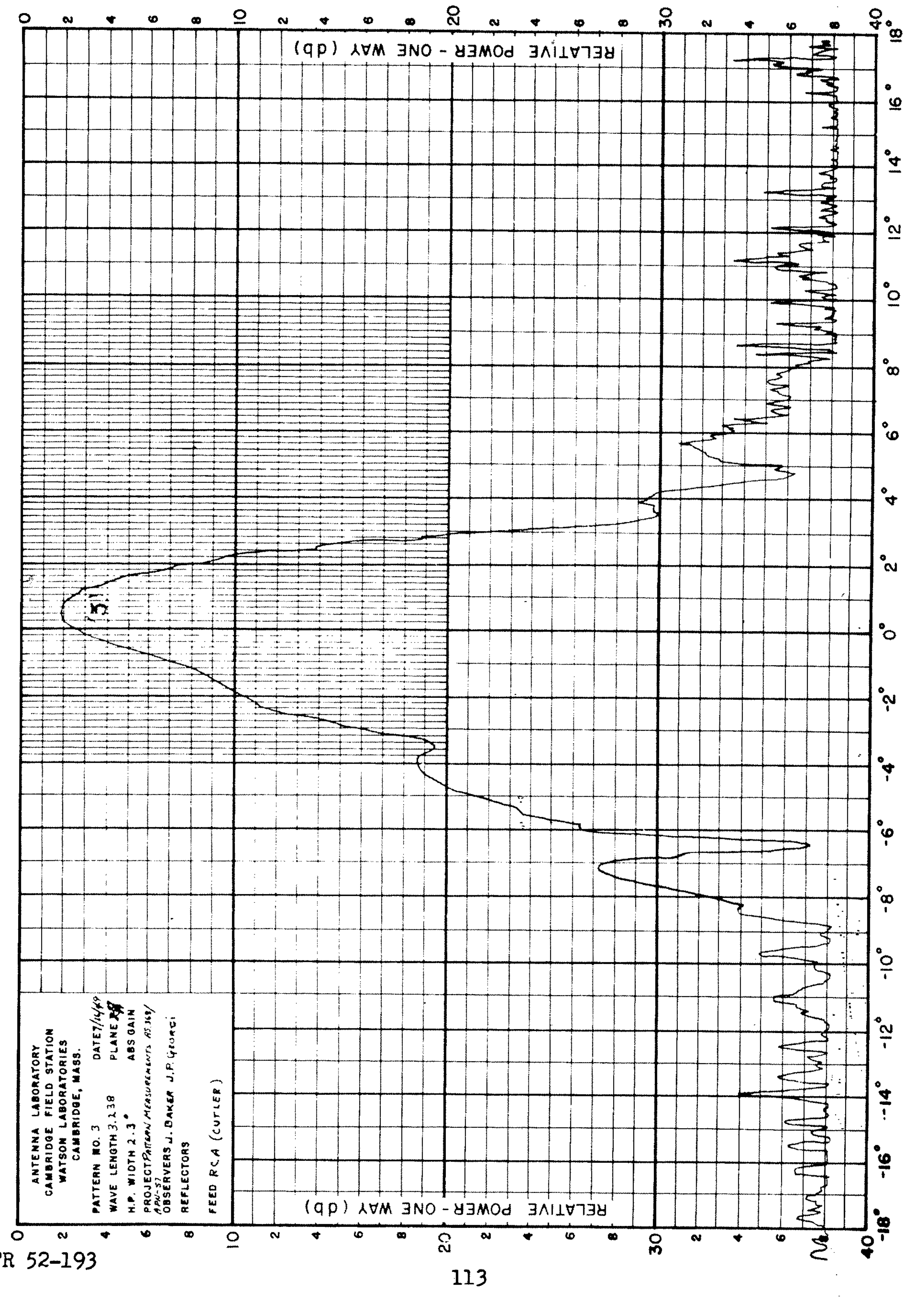


Fig. 30. Antenna Patterns, Antenna Assembly AS-368/APN-57

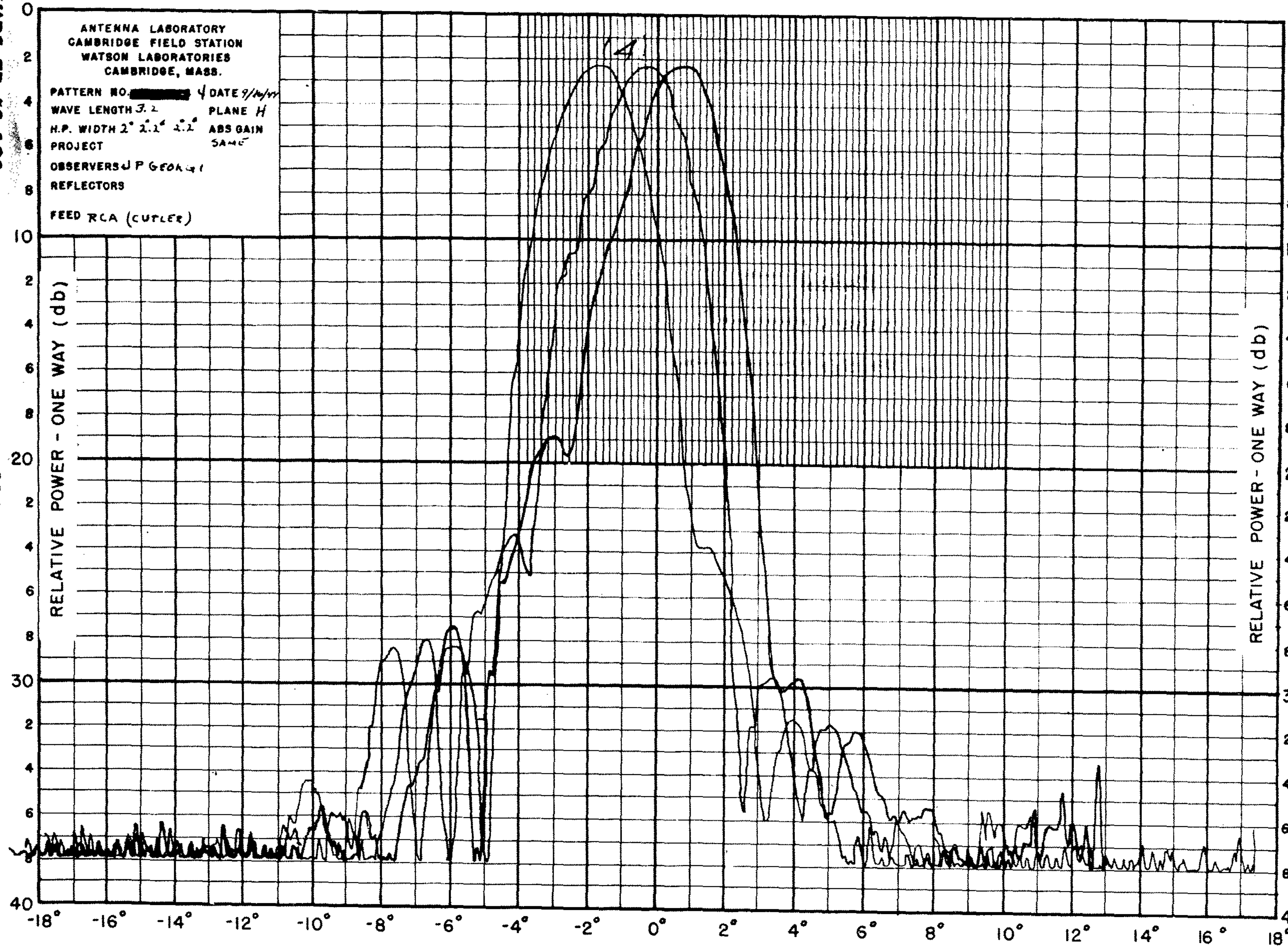


Fig. 31. Antenna Patterns, Antenna Assembly AS-368/APN-57

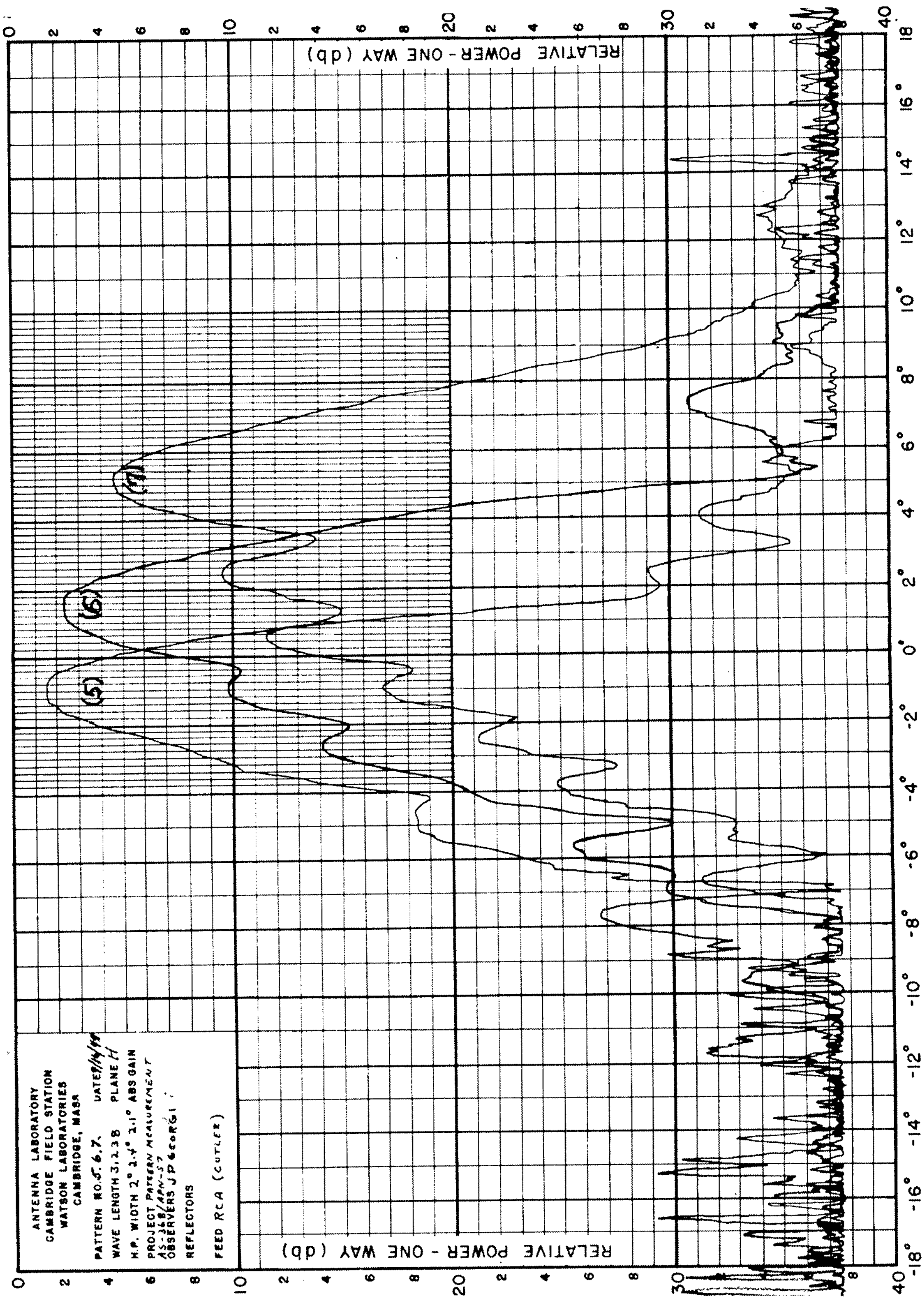


Fig. 32. Antenna Patterns, Antenna Assembly AS-368/APN-57

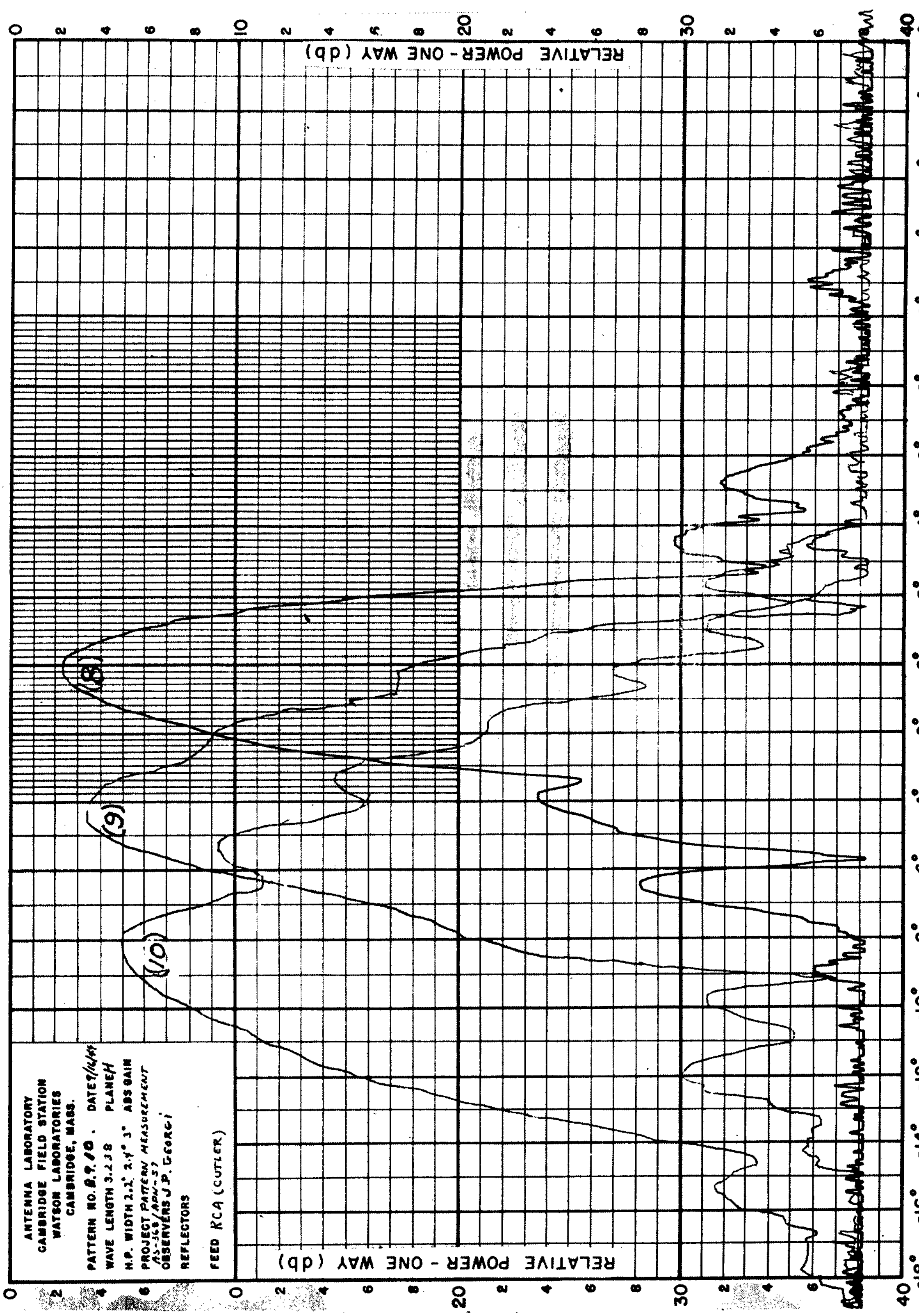


Fig. 33. Antenna Patterns, Antenna Assembly AS-368/APN-57

APPENDIX IX

LIFE TEST -- LIST OF PART FAILURES

Set No. 1 (RT #4 with Ind. #1) and Set No. 2 (RT #3 with Ind. #15)

Circuit Ref. No.	Component and Function	Nature of Failure
T230	Low-voltage transformer	Burned out
V231	Low-voltage rectifier (6X5GT)	Shorted
V702	Circle amplifier (6AQ5)	Low emission
R705	Circle amplifier cathode resistor	Resistance increased
V273	Modulator rectifier (3B24)	Open filament
R276	Primary series resistor	Burned out
T270	Modulator power supply transformer	Shorted secondary
T270	"	"
T270	"	"

Set No. 3(RT #12 with Ind. #13) and Set No. 4 (RT #11 with Ind. #16)

Circuit Ref. No.	Component and Function	Nature of Failure
----	Shaft coupling insulator	Broken
V415	3 kc amplifier (2C51)	Grid/cathode short
V350	TR tube (1B24)	Defective
B270	Blower motor	Shorted
----	Cyclic AGC cable	Shorted
R276	see above	Burned out
T270	"	Shorted secondary
V601	Frequency divider (2C51)	Defective
V702	Circle amplifier (6AQ5)	Defective

V402	Low-voltage rectifier (5R4GY)	Open filament
L401	Filter choke	Burned out
V233	TR keep-alive rectifier (9006)	Defective
Y351	AFC crystal	Burned out
W382	Trigger cable	Shorted
V271	Modulator (3C45)	Defective
Y350	Mixer crystal	Burned out
K401	Delayed B+ relay	Grounded
V401	Low-voltage rectifier (5R4GY)	Open filament
Z402	Delay line	Open
V425	Phase detector (2D21)	Defective
W406	I-f input cable	Broken
V423	3 kc square wave delay (6AQ5)	Defective
V352	Local oscillator (723A/B)	Defective
T270	Modulator power supply transformer	Shorted secondary
T270	"	Prim./sec. short
C404	Regulated B+ filter	Impregnant leaked
Z402	Delay line	Shorted
V423	3 kc square wave delay (6AQ5)	Defective
T401	Low-voltage power transformer	Primary open and shorted to sec.

Note: Grouped components represent a simultaneous breakdown.

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